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Idaho Operations Office

Engineering Evaluation/Cost Analysis for Decommissioning of the Engineering Test Reactor Complex

October 2006

Idaho Cleanup Project

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Prepared for the
U.S. Department of Energy
DOE-ID Operations Office

ABSTRACT

Preparation of this Engineering Evaluation/Cost Analysis is consistent with the joint U.S. Department of Energy and U.S. Environmental Protection Agency *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act*, which establishes the Comprehensive Environmental Response, Compensation, and Liability Act non-time-critical removal action (NTCRA) process as an approach for decommissioning. This removal action is consistent with the remedial action objectives of the *Final Record of Decision Test Reactor Area Operable Unit 2-13* or the *Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13*. The removal action will place the facility in a final configuration that remains protective of human health and the environment.

The purpose of this NTCRA process is to determine:

- The final end state of the TRA-642 Engineering Test Reactor (ETR) reactor building abovegrade and belowgrade structure
- The final disposition of the ETR vessel
- The risks to human health and the environment associated with leaving contamination at the ETR Complex.

The recommended removal action includes removing and disposing of the ETR vessel at the Idaho CERCLA Disposal Facility and demolishing the reactor building to ground surface. This is Alternative 3 of four alternatives considered in this evaluation.

EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) for decommissioning the Engineering Test Reactor (ETR) Complex has been prepared for public comment. The evaluation assists the U.S. Department of Energy Idaho Operations Office (DOE-ID) with identifying the most effective approach for the final decommissioning of the ETR vessel and remaining structures, whose missions have been completed. The process to accomplish this decommissioning and to determine the final end state is to perform a non-time-critical removal action (NTCRA). The approach satisfies environmental review requirements and provides for stakeholder involvement while providing a framework for selecting the decommissioning alternative. The approach also establishes an Administrative Record for documentation of the removal action.

Development of this EE/CA has been performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.), as amended by the "Superfund Amendments and Reauthorization Act of 1986" (Public Law 99-499), and in accordance with the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 Code of Federal Regulations [CFR] 300). Although decommissioning of the ETR Complex was not specifically addressed in the Final Record of Decision Test Reactor Area Operable Unit 2-13 (DOE-ID 1997) or the *Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13* (DOE-ID 2000), this removal action is consistent with the remedial action objectives of the Record of Decision and supports the overall remediation goals established through the Federal Facility Agreement and Consent Order (DOE-ID 1991) process for Waste Area Group 2. Waste Area Group 2 is located at the Reactor Technology Complex (RTC) within the Idaho National Laboratory (INL), formerly known as the Test Reactor Area (TRA) and Idaho National Engineering and Environmental Laboratory, respectively. The removal action will place the facility in a final configuration that remains protective of human health and the environment. Preparation of this EE/CA is consistent with the joint U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act* (DOE and EPA 1995), which establishes the CERCLA NTCRA process as an approach for decommissioning.

Deactivation of the ETR Complex was initiated in December 1981. The fuel in the ETR, as well as irradiated fuel in the ETR storage canal, was removed and shipped to the Idaho Nuclear Technology and Engineering Center for storage.

The scope of this EE/CA is the final end state of the ETR Complex and final disposal site for the ETR vessel. A continuation of the deactivation activities that were begun in 1981 are proceeding in advance of the NTCRA Action Memorandum and are not included in the scope of the NTCRA. These initial activities involve removal of some piping and equipment, and routine waste management practices such as removal of lead, polychlorinated biphenyls, and asbestos. In addition, some demolition of support buildings and structures is proceeding in advance of the NTCRA. It is important to understand that a substantial amount of work will have been completed under this phase, prior to finalization of this EE/CA. Therefore, the purpose of the NTCRA process is to determine:

- The final end state of the TRA-642 ETR reactor building abovegrade and belowgrade structure
- The final disposition of the ETR vessel
- The risks to human health and the environment associated with leaving contamination at the ETR Complex.

Four alternatives are under consideration for the ETR Complex NTCRA:

- Alternative 1, the no action alternative, is included for completeness and comparative purposes. However, the alternative only defers taking further action at the ETR Complex to a future date and does not address the potential for adverse threat to human health and the potential threat of release of hazardous substances to the environment. It is not recommended for these reasons.

- Alternative 2 grouts the ETR vessel in place. Because this alternative does not meet the threshold criteria for protectiveness of human health, it cannot be recommended.

Only Alternatives 3 and 4 were evaluated to determine the recommended alternative.

- Alternative 3 removes the ETR vessel and demolishes the reactor building to ground surface. The ETR vessel would be disposed of at an on-Site disposal facility (Idaho CERCLA Disposal Facility or Radioactive Waste Management Complex). This alternative meets the remedial action objectives established in the Operable Unit 2-13 Record of Decision. Alternative 3 provides the most protection for the worker and costs less.

- Alternative 4 also removes the ETR vessel, demolishes the reactor building to ground surface and meets the remedial action objectives; however, the ETR vessel would be disposed of at the Nevada Test Site. Compared to Alternative 3, Alternative 4 has greater risk for the worker and costs more.

The recommended removal action alternative is Alternative 3 which includes removal and disposal of the ETR vessel at the Idaho CERCLA Disposal Facility. The reactor building would be demolished to ground surface and structures and systems below ground surface, consisting of inert materials such as piping, structural metal, and utility systems, would be abandoned in place. Residual radioactive materials in the ETR Complex remaining after decommissioning activities are completed would remain in place and would be managed under the Sitewide Institutional Control Program. Reactor building void spaces would be backfilled as practicable, including the void left by removal of the ETR vessel. Backfill would consist of grout, as necessary, inert demolition waste from the abovegrade structures, and clean backfill materials. The vessel would be grouted to stabilize the internal reactor components during transportation and meet required Idaho CERCLA Disposal Facility Waste Acceptance Criteria for reducing void space to prevent subsidence.

This EE/CA will become part of the INL Administrative Record. Documentation supporting this EE/CA, such as the Engineering Design Files, will also be included in the Administrative Record. The INL Administrative Record is on the Internet at http://ar.inel.gov/ and is available to the public at the following locations:

Albertsons Library	INL Technical Library
Boise State University	DOE Public Reading Room
1910 University Drive	1776 Science Center Drive
Boise, ID 83725	Idaho Falls, ID 83415
(208) 426-1625	(208) 526-1185

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CRMP	Cultural Resources Management Plan
D&D	decommissioning and demolition
DEQ	(Idaho) Department of Environmental Quality
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
DOT	Department of Transportation
EBSL	ecologically based screening level
EDF	Engineering Design File
EE/CA	engineering evaluation/cost analysis
EPA	Environmental Protection Agency
ETR	Engineering Test Reactor
GEEL	General Electric Experimental Loop
HWMA	Hazardous Waste Management Act
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project
IDAPA	Idaho Administrative Procedures Act
INL	Idaho National Laboratory
LLW	low-level waste
MCL	maximum contaminant level
NCRP	National Council on Radiation Protection
NHPA	National Historic Preservation Act
NRC	Nuclear Regulatory Commission
NTCRA	non-time-critical removal action
NTS	Nevada Test Site
OU	operable unit
PCB	polychlorinated biphenyl

PCS	primary cooling system
RAO	remedial action objective/removal action objective
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex
SRPA	Snake River Plain Aquifer
SSL	soil screening level
TRA	Test Reactor Area
TSCA	Toxic Substances Control Act
USC	United States Code
VCO	Voluntary Consent Order
WAC	Waste Acceptance Criteria

Engineering Evaluation/Cost Analysis for Decommissioning of the Engineering Test Reactor Complex

1. INTRODUCTION

This Engineering Evaluation/Cost Analysis (EE/CA) has been prepared in accordance with Section 300.415(b)(4)(i), "Removal Action," of the "National Oil and Hazardous Substances Pollution Contingency Plan" (40 Code of Federal Regulations [CFR] 300) and assists the U.S. Department of Energy Idaho Operations Office (DOE-ID) with identifying the most effective alternative for decommissioning the Engineering Test Reactor (ETR) Complex, whose mission is now completed. The ETR vessel is located in the Reactor Technology Complex (RTC), formerly Test Rector Area, TRA-642 reactor building. The process to accomplish this decommissioning and to determine the end state of the ETR Complex and final disposal site for the ETR vessel is to perform a non-time-critical removal action (NTCRA). It is intended to satisfy environmental review requirements while providing a framework for selecting the decommissioning end states and satisfying Administrative Record requirements for documentation of the removal action. This EE/CA identifies the objectives of the removal action and analyzes the effectiveness, implementability, and estimated cost of the proposed action to satisfy these objectives. Following the issuance of this EE/CA for public comment and consideration of comments received during the public review period, an Action Memorandum documenting the selected alternative will be issued to the Administrative Record by DOE-ID with concurrence from the Idaho Department of Environmental Quality (DEQ) and U.S. Environmental Protection Agency (EPA).

This action is consistent with the joint U.S. Department of Energy (DOE) and EPA *Policy on Decommissioning of Department of Energy Facilities Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* (DOE and EPA 1995), which establishes the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) NTCRA process as an approach for decommissioning. The policy states, in part:

> Although the full range of CERCLA response actions may be applicable to decommissioning activities, non-time critical removal actions should be used for decommissioning, consistent with this Policy. The alternative approaches available to conduct decommissioning projects typically are clear and very limited. This often will eliminate the need for the more thorough analysis of alternatives required for remedial actions. Non-time critical removal action requirements provide greater flexibility to develop decommissioning plans that are appropriate for the circumstances presented. Statutory time and dollar limits on removal actions do not apply to removal actions conducted by DOE, which increases the scope of projects that may be addressed by DOE removal action. Most importantly, non-time critical removal actions usually will provide benefits to worker safety, public health, and the environment more rapidly and cost-effectively than remedial actions. For these reasons, DOE may exercise removal action authority to conduct decommissioning whenever such action is authorized by CERCLA, the NCP, and Executive Order 12580.

Performance of this removal action will place the facilities in a configuration that is protective of human health and the environment. Without decommissioning of the ETR Complex, a potential threat of release of hazardous substances exists, and, without action, adverse threats to human health and the environment eventually could occur. As the lead agency, DOE has determined that a removal action is an appropriate means to accomplish the final end state and achieve environmental review requirements.

Both the DEQ and the EPA concur that a NTCRA is warranted to place the ETR Complex in a final configuration that is protective of human health and the environment.

1.1 Scope and Purpose of the ETR Complex EE/CA

The scope of this EE/CA is the final end state of the ETR Complex and final disposal site for the ETR vessel. Deactivation activities that were begun in 1981 and are continuing in advance of the NTCRA Action Memorandum are not included in the scope of the NTCRA. These deactivation activities involve removal of piping and equipment, and routine waste management practices such as removal of lead, polychlorinated biphenyls (PCBs) and asbestos. In addition, some demolition of support buildings and structures has been completed.

It is important to understand that a substantial amount of work will have been completed under the deactivation activities phase prior to finalization of this EE/CA. Deactivation and demolition activities are ongoing as this EE/CA is being prepared; material and contamination estimates used in this EE/CA were generally estimates of what was in the ETR Complex prior to starting these activities. Much of the materials and contamination may be removed during this initial phase but were included in the EE/CA risk evaluations to ensure a conservative approach was taken for determining risk to human health, groundwater, and the environment for the proposed end-state alternatives evaluated in this EE/CA. Therefore, the purpose of the NTCRA process is to determine:

- The final end state of the TRA-642 ETR reactor building abovegrade and belowgrade structure
- The final disposition of the ETR vessel
- The risks to human health and the environment associated with leaving contamination at the ETR Complex.

2. SITE CHARACTERIZATION

This section provides summary background information and a description of the ETR Complex. This section identifies previous and ongoing closure and cleanup activities, including a description of the buildings and structures that are addressed in this EE/CA and additional information relevant to the scope of this EE/CA. This section also provides a summary of the radiological and nonradiological characterization of the ETR Complex.

2.1 Site Description and Background

2.1.1 Idaho National Laboratory Site and Idaho Cleanup Project

The Idaho National Laboratory (INL) Site, managed by DOE, is located 51 km (32 mi) west of Idaho Falls, Idaho. The INL Site occupies 2,305 km^2 (890 mi^2) of the northeastern portion of the Eastern Snake River Plain. In 1949, the U.S. Atomic Energy Commission established the INL Site, which was called the National Reactor Testing Station at that time. Its purpose was to conduct nuclear energy research and related activities. It was redesignated the Idaho National Engineering Laboratory in 1974 and then the Idaho National Engineering and Environmental Laboratory in 1997. In 2005, to better focus the laboratory's missions, DOE established the Idaho Cleanup Project (ICP) to bring the environmental management mission to completion and redesignated the site as the INL to better reflect the laboratory's new research directions.

DOE-ID controls all land within the INL Site. Public access is restricted to public highways, sponsored tours, special-use permits, and the Experimental Breeder Reactor I National Historic Landmark. In addition, DOE-ID is cognizant of the Shoshone-Bannock tribal members' need for access to areas on the INL Site for cultural and religious purposes.

The INL Site is located primarily in Butte County; however, it also occupies portions of Bingham, Bonneville, Clark, and Jefferson counties. The 2000 census indicated the following populations for cities in the region: Idaho Falls–50,730; Pocatello–51,466; Blackfoot–10,419; Arco–1,026; and Atomic City–25.

Surface water flows on the INL Site consist mainly of three streams draining intermountain valleys to the north and northwest of the INL Site: (1) the Big Lost River, (2) the Little Lost River, and (3) Birch Creek. All of the channels terminate on the INL Site. Flows from Birch Creek and the Little Lost River seldom reach the INL Site because of irrigation withdrawals upstream. The Big Lost River and Birch Creek may flow onto the INL Site before the irrigation season or during high-water years, but the terminal reaches are usually dry. In those few wetter years when the Big Lost River carries water to the end of its channel, the water sinks into the ground.

The physical characteristics, climate, flora and fauna, demography, and cultural resources of the INL Site and RTC area are further described in the Final Record of Decision for TRA Operable Unit (OU) 2-13 (DOE-ID 1997).

2.1.2 Reactor Technology Complex Area

The RTC is shown in Figure 2-1 and has served to house high-neutron-flux nuclear reactors and to test the effect of irradiation upon materials, fuels, and equipment. The complex was established in the early 1950s with the development of the Materials Testing Reactor (which is located in the TRA-603 building). Two other major reactors followed: the ETR, which is located in the TRA-642 building, and the Advanced Test Reactor, which is located in TRA-670. Removal of the fuel rods from Materials Testing Reactor and ETR began soon after reactor operations ceased, in 1970 and 1981, respectively. Only the Advanced Test Reactor is currently operational.

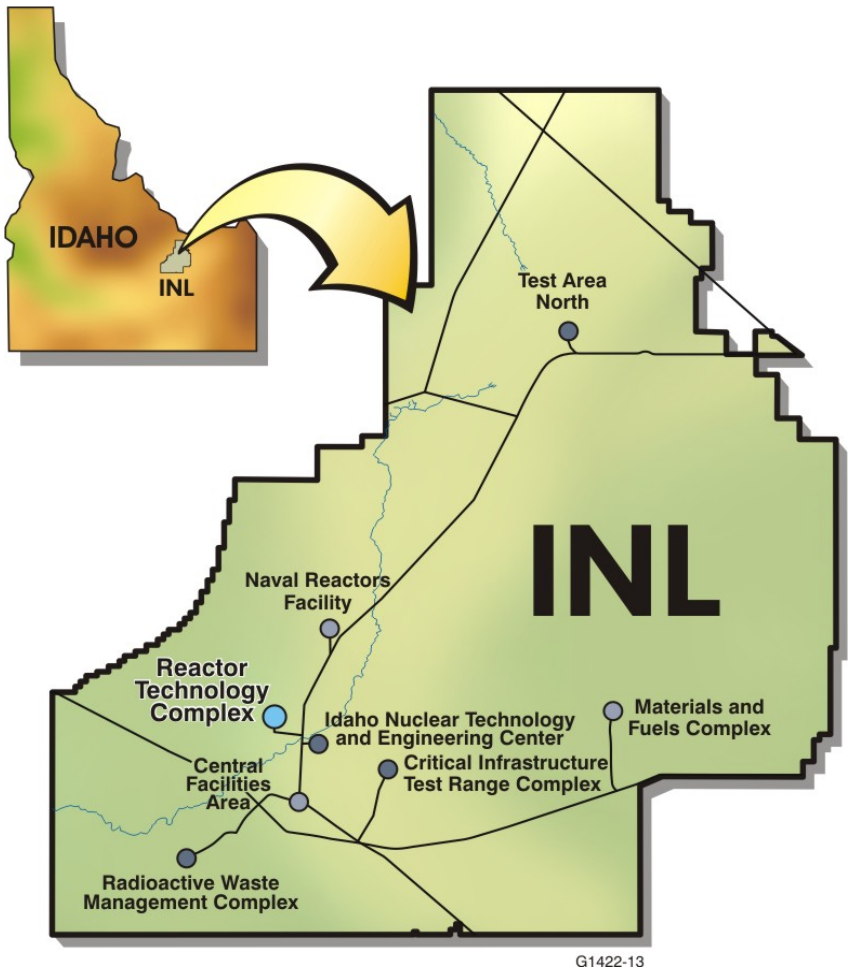

Figure 2-1. Map of the Idaho National Laboratory Site showing the location of the Reactor Technology Complex and other major facilities.

2.1.3 Engineering Test Reactor Complex

The scope of this EE/CA includes an evaluation of the risks to human health and the environment if contamination is left in place at the ETR Complex to determine the appropriate final end state of the complex. This section describes the buildings and structures where radionuclides and nonradiological constituents included in the contaminant source terms used in the risk evaluations reside. This section also includes some operational history and history of past deactivation and decommissioning activities that have taken place associated with those ETR Complex buildings and structures. Many of the aboveground structures have already been demolished; this EE/CA evaluates contaminants that may exist in the belowground structures.

The ETR Complex (Figure 2-2) first became operational in 1957. At the time it entered service, it was the largest, most advanced nuclear fuels and materials test reactor in the United States at 175 MWth (megawatt thermal). After initial testing of the reactor, full power operation was achieved in 1958. In 1972, a decision was made to have the ETR support the DOE's breeder reactor safety program. Conversion of the reactor for this purpose started in May 1973. The new assignment focused on safety programs relating to reactor fuel, core design, and operation for the liquid metal fast-breeder reactor program. Figure 2-2 shows the locations of buildings and structures composing the ETR Complex.

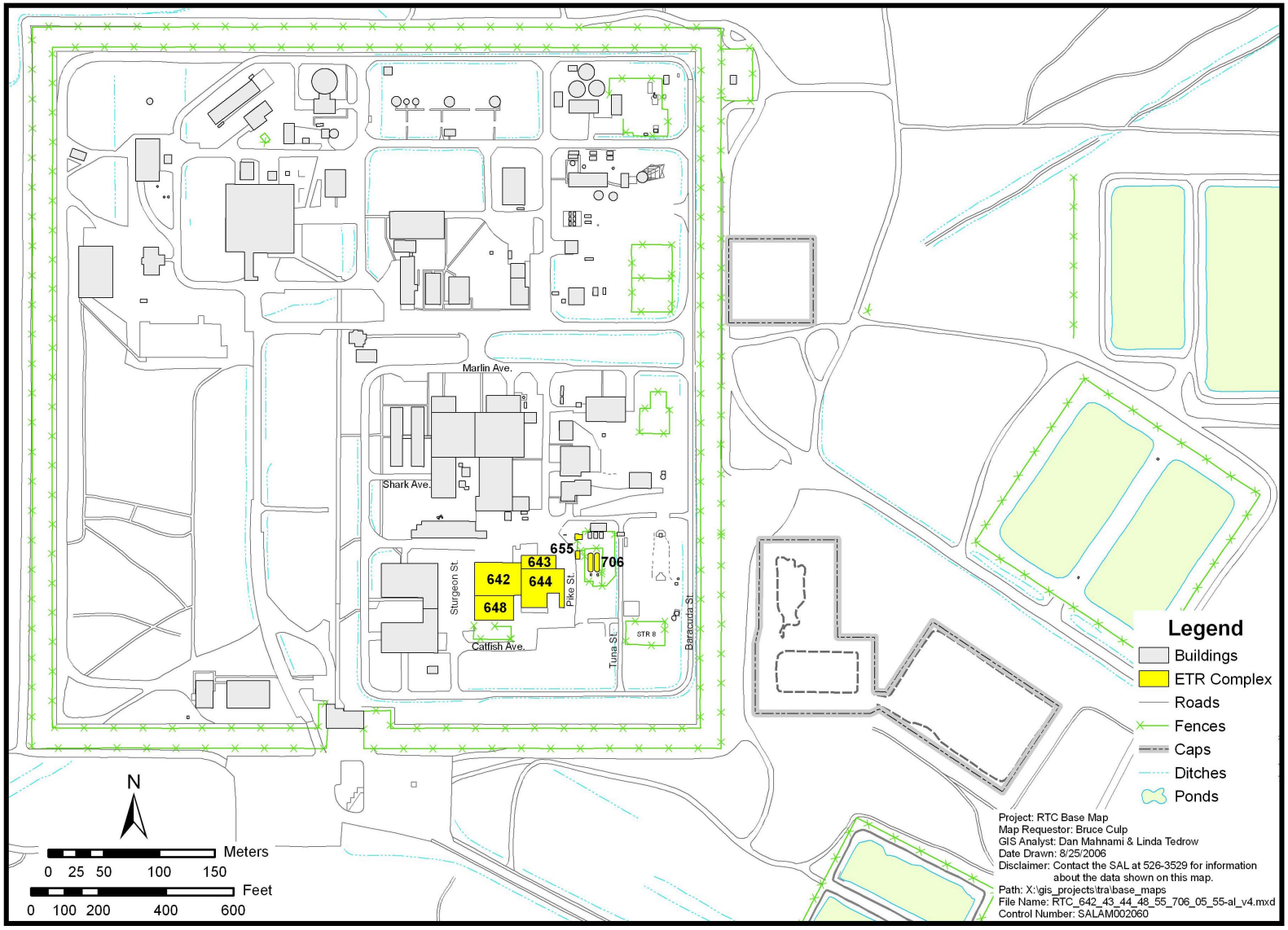

Figure 2-2. Map of the Reactor Technology Complex with the Engineering Test Reactor Complex highlighted.

Deactivation of the ETR Complex was initiated in December 1981. The neutron startup source was removed. Radioactive water was drained from the ETR vessel, primary coolant system (PCS), water loop experiment piping and vessels, both canal sections, degassing tank and associated piping, and resin tanks. Other water systems were drained, including the secondary coolant water (including heat exchangers), utility water, the two demineralized water systems (low and high pressure), and water in heating and cooling units. The fuel in the ETR, as well as irradiated fuel in the ETR storage canal, was removed and shipped to the Idaho Nuclear Technology and Engineering Center for storage.

2.1.3.1 Engineering Test Reactor Building. The ETR reactor building (TRA-642) has four levels, as shown in Figure 2-3. The main hall, which comprises the abovegrade portions (Figure 2-4) of the building, provides access to the uppermost section of the ETR vessel and the top of the ETR storage canal. The three underground levels are comprised of the console level and pipe tunnel, the basement with the experiment cubicles and a subpile room, and a lowermost level containing the control rod access room. The main features of radiological concern for this EE/CA in the reactor building are the ETR vessel, experimental cubicles, and warm and hot waste tanks and vaults.

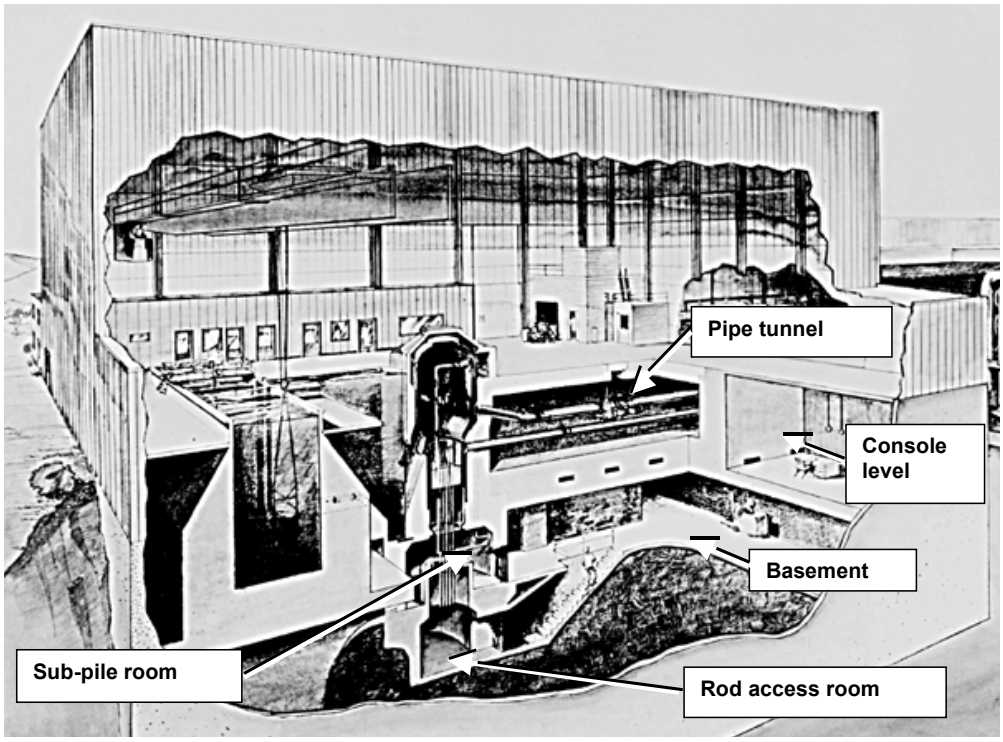

Figure 2-3. Cutaway rendering of the Engineering Test Reactor building (TRA-642) looking north.

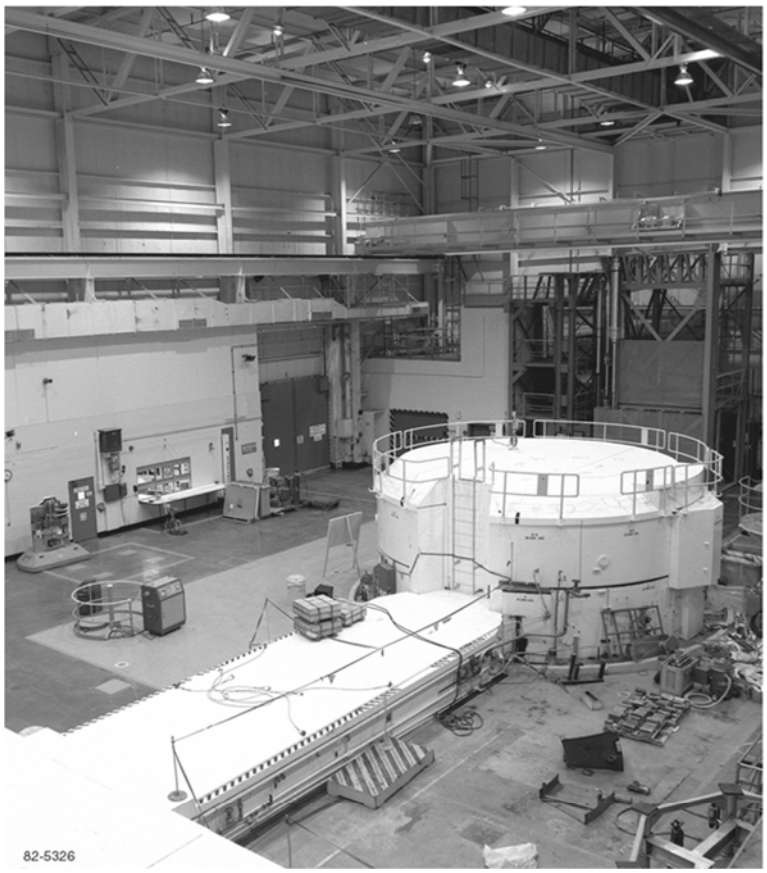

Figure 2-4. Main reactor room with the biological shield shown covering the ETR vessel.

This EE/CA evaluates the end state of the reactor building including human health and environmental risk associated with radiological and nonradiological constituents. The reactor building, including all three underground levels, will essentially be intact at the end of the deactivation activities and the beginning of the NTCRA action phase of decommissioning. Much, if not all, of the regulated hazardous wastes will be removed prior to the NTCRA. As is detailed in later sections of this EE/CA, 99.999% of the radiological inventory of the ETR Complex resides in the ETR vessel; the remaining radiological constituents are located on surfaces and in pipes associated with the complex buildings and structures.

2.1.3.2 ETR Vessel. The ETR vessel is a multidiameter, cylindrical vessel approximately 36 ft in height and 12 ft in diameter at the top, reducing down to 7 ft in diameter at the bottom (Figure 2-5). As stated above, all fuel has been removed from the ETR vessel. Major internal components remaining in the vessel include the control rod guide tubes, control rod sections, aluminum and beryllium reflector, grid plate, and four in-pile tubes. The vessel also contains miscellaneous fillers, adapters, and plugs. The ETR vessel with the internal components weighs approximately 82 tons.

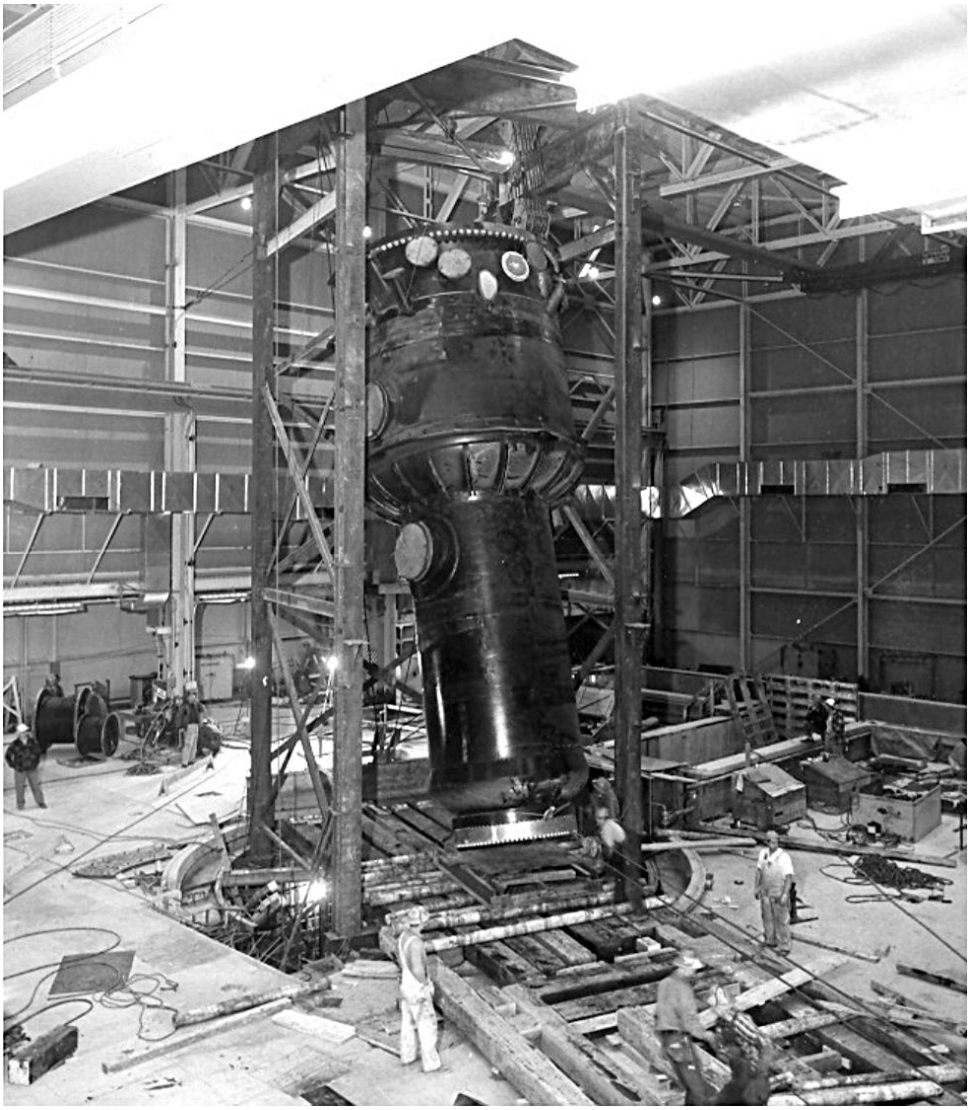

Figure 2-5. Engineering Test Reactor vessel installation in 1956.

2.1.3.3 Experiment Cubicles. The basement is subdivided into a number of cubicles. Cubicle walls and the wall surrounding the ETR vessel are high-density concrete (e.g., contains magnetite). Other walls are standard concrete. The cubicles themselves had various pipes, tanks, and instruments to support the various experiments. Figure 2-6 shows the basement floor plan of the TRA-642 reactor building, the experimental cubicles, and warm and hot waste pits. The deactivation activities removed lead (over 735,000 lb), asbestos, and contaminated piping from the cubicles walls and shielded piping runs.

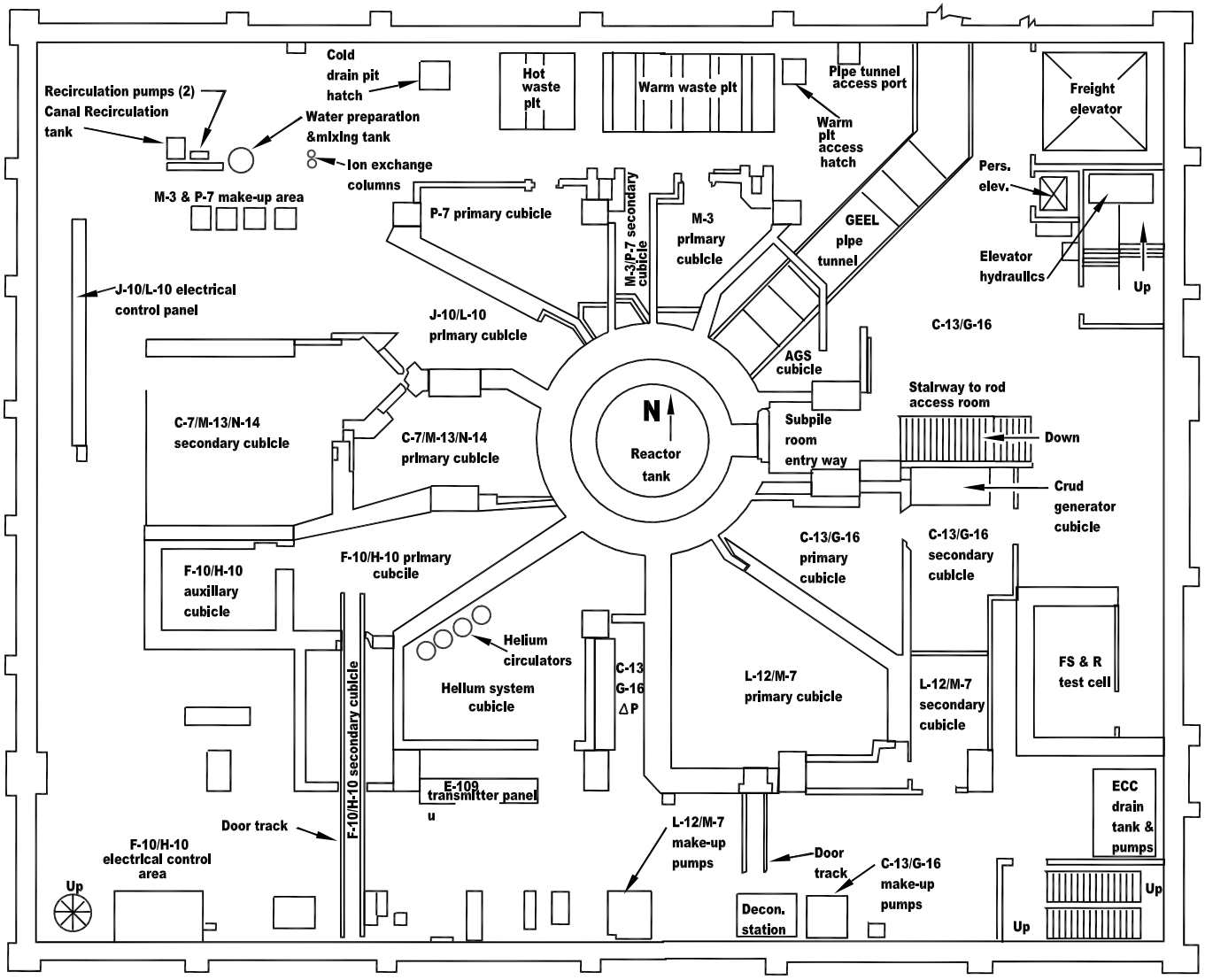

Figure 2-6. Basement floor plan of the TRA-642 reactor building showing the experiment cubicles.

2.1.3.4 Warm and Hot Waste Pits. Two unlined pits were built below the basement floor of the ETR reactor building. One of these, referred to as the hot waste pit, houses a 1,000-gal cold waste tank and a 500-gal hot waste tank. The hot waste tank was removed in 2005 as part of a Voluntary Consent Order (VCO) (DEQ 2000) closure. The other unlined pit, referred to as the warm waste pit, holds a 5,000-gal warm waste tank. These pits are located just inside the north wall of the reactor building. The remaining warm and cold waste tanks will be drained of any residual liquids and grouted in place.

2.1.3.5 Engineering Test Reactor Compressor Building (TRA-643). The TRA-643 building was the compressor building that housed the equipment used to supply large quantities of heated, hydrocarbon-free air to various experiments. The building contained a process control room that was used to control plant services to the reactor and the sample laboratory that was used to conduct chemistry samples on the reactor primary and secondary coolant systems. The building also contained a storage area for experiment spare parts, handling tools, and lifting fixtures.

TRA-643 was demolished during the continuing deactivation phase. Hazardous wastes and asbestos were removed and disposed of prior to demolition.

2.1.3.6 Engineering Test Reactor Heat Exchanger Building (TRA-644). The ETR heat exchanger building (TRA-644) was adjacent to and east of the reactor building and south of the compressor building. The building included (1) a main room and lower level, (2) a demineralizer wing (valve room and tank room), (3) a degassing tank room, (4) a cubicle-exhaust booster blower room, and (5) a secondary pipe pit. The primary function of the heat exchanger building main room was to house the 12 primary coolant/secondary coolant system heat exchangers and associated piping.

TRA-644 was demolished to below ground surface during the continuing deactivation phase. Hazardous wastes and asbestos were removed and disposed of prior to demolition. The heat exchangers, including most of the associated secondary and primary coolant piping, were removed and disposed of prior to demolition. The secondary pump pit was backfilled with clean fill. Only small amounts of mostly fixed contamination remained on building surfaces prior to demolition. This source term, as well as all remaining source terms after demolition was complete, was included in the risk evaluation.

2.1.3.7 Other Engineering Test Reactor Complex Structures. Several smaller ancillary structures at the ETR Complex supported reactor operations. These structures are comprised of the following:

- TRA-648—Electrical Building: The TRA-648 electrical building housed the major electrical equipment for the ETR facility. Equipment remaining in the building includes switchgear, Emergency Diesel Generator No. 1, five motor-generator units, and a battery bank.

  This building has had the hazardous wastes and asbestos removed during the deactivation activities. The basement areas of TRA-648 contain a cable vault that contained electrical cables and components and a fan room that housed the large blowers that provided ventilation. Small areas of loose and fixed contamination remain in the basement areas of TRA-648. The building is being used as a tool storage area and will be demolished either prior to or during the NTCRA.

- TRA-706—Delay Tank Vault and Delay Tanks: This underground vault, located to the northeast of the TRA-643 compressor building, houses the delay tanks. The delay tanks are baffled tanks that were used to delay exhaust flow, allowing for the radioactive decay of short-lived radionuclides in the exhaust air. The tanks are 20 ft below ground surface and contain low levels of radiological constituents.

The radiological source term for these tanks has been included in the risk evaluations, and the end states of these tanks will be determined through this EE/CA process.

- General Electric Experimental Loop (GEEL) Pipe Tunnel: The GEEL tunnel extends northeast from the reactor core. This tunnel was installed to allow ducts from the GEEL to exit the reactor building. The tunnel begins beneath the reactor building basement floor, runs under the annulus gas system cubicle, then underground north and east of the reactor building, and ends at the delay tanks. Hazardous wastes and asbestos have been removed from the GEEL tunnel. The final end state of the GEEL, including radiological constituents, will be determined through this EE/CA process.

- TRA-704, TRA-705, and TRA-755 Filter Pits: The filter pits contained large air filters that filtered the air in the exhaust systems from ETR-642 cubicles prior to it being exhausted from the ETR stack. The filters have been removed and disposed of and the unlined concrete vaults will be demolished to below grade and backfilled.

2.2 Previous Closure/Cleanup Activities at the Engineering Test Reactor Complex

2.2.1 Comprehensive Environmental Response, Compensation, and Liability Act Activities at the Reactor Technology Complex

The CERCLA Final Record of Decision for TRA OU 2-13 (DOE-ID 1997) and *Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13* (DOE-ID 2000) selected a remedy for the cleanup of identified contaminated soil at the RTC. Remedies also were selected for the warm waste pond, perched water system, chemical waste pond, and sewage leach pond. Remedial actions specified by the Record of Decision (ROD) (DOE-ID 1997) have been completed at Waste Area Group 2 and, as required under CERCLA (42 United States Code [USC] § 9601 et seq.) whenever contamination is left in place, institutional controls have been implemented for residual contaminants left in place at concentrations that would not allow for unrestricted use or access. Fifteen sites were found to require institutional controls to ensure adequate protection of human health and the environment. The Explanation of Significant Differences (DOE-ID 2000) discusses implementation, maintenance, and monitoring of institutional controls at each RTC site in detail.

Groundwater monitoring under CERCLA has been ongoing at the RTC in accordance with the requirements of the OU 2-12 and OU 2-13 RODs (DOE-ID 1992, 1997). On October 7, 1991, the EPA designated the Snake River Plain Aquifer (SRPA) a sole-source aquifer under the Safe Drinking Water Act (42 USC § 300f et seq.). Although the SRPA and perched water beneath the RTC are listed as No Further Action sites, they are monitored extensively, because changes in these sites could be indicative of the effectiveness of the remedies in place at the OU 2-13 sites or could indicate the occurrence of a new release.

2.2.2 Voluntary Consent Order Activities

The VCO Program was responsible for characterizing many of the support systems associated with the ETR that may have included Resource Conservation and Recovery Act (RCRA) (42 USC § 6901 et seq.) hazardous wastes. These included the waste systems (hot, warm, and cold), the ETR vessel, the PCS, the experimental water loop systems, the water makeup system for the M3/P7 experimental loops, the Sodium Loop Safety Facility helium cooling system, the experimental air system, the GEEL system, and the diesel generator system. All these systems were either characterized in accordance with

Hazardous Waste Management Act (HWMA) (Idaho Code § 39-4401 et seq.) and RCRA regulations or verified as empty process/product tanks. The hot waste storage tank associated with the hot waste system was found to contain hazardous solids and has subsequently undergone HWMA/RCRA closure. The hot waste storage tank and a lead shield wall that was surrounding the tank were removed. All solids that had accumulated in the hot sump pit vault also were removed and the vault was put back into service to manage nonhazardous water infiltration.

The filling, storage, and remelt charging facility included a number of small tanks and ancillary piping that contained sodium and sodium-potassium alloy, both of which exhibited a reactive characteristic This charging facility has been HMWA/RCRA closed.

The secondary pipe pit sump (TRA-644-48) was characterized as nonhazardous per RCRA regulations; however, the sump was identified as a potential release source of 40 CFR 261, Appendix VIII, constituents to the environment. The secondary pipe pit sump residuals have been accounted for in the ETR source term inventories included in Section 2.3.1. Including this secondary pipe pit in this EE/CA satisfies the need for preparing and submitting this as a potential new release site under the Federal Facility Agreement and Consent Order.

An ion exchange vessel and associated ancillary piping from the P-7 experimental water loop system were found to contain hazardous waste and have subsequently undergone HWMA/RCRA closure. The rod drive's access room sump was found to contain hazardous solids, which have been removed and appropriately dispositioned. Seven of the filters associated with the GEEL system were removed and managed as hazardous waste, because lead was a material of construction and the fact that four of the filter units still contained silver-impregnated filter media.

2.2.3 Deactivation Activities

Deactivation activities are proceeding in advance of the NTCRA Action Memorandum and are not included in the scope of the NTCRA. In addition to the deactivation activities, utility isolations and demolition of buildings and support structures (with the exception of the TRA-642 reactor building) is ongoing. Prior to demolition of these structures, the following will have been performed:

1. Hazardous Waste Removal: Hazardous waste—such as acidic or caustic material, mercury vapor lamps and fluorescent bulbs, lead shielding, circuit boards containing lead and/or silver soldering, and waste regulated under the Toxic Substances Control Act (TSCA) (15 USC § 2601 et seq.) such as PCB articles and equipment (e.g., transformers, capacitors, and fluorescent lighting ballasts might contain PCBs)—is removed and disposed of. Other hazardous and toxic waste may be removed during deactivation activities, as discovered during performance of these activities.

2. Asbestos Abatement Activities: Deactivation activities also include removal of friable asbestos that might be found in pipe and tank/vessel insulation, fire doors, transite panels, and other potential asbestos-containing material, as required under 40 CFR 61.145, "Standard for Demolition and Renovation."

3. Removal of Other Support Systems and Components from the ETR Complex: These activities include draining or emptying systems containing liquids and removing electrical cabinets, hoods, sinks, mixing tanks, and counters. These activities also include deenergizing and isolating utilities and reconfiguring those systems (as necessary) to support continuing RTC operations. In addition, chlorofluorocarbons used as refrigerants will be removed in accordance with the requirements of Section 609 of the Clean Air Act (42 USC § 7401 et seq., as amended).

2.3 Extent of Contamination and Remaining Inventories

In the current state, the ETR Complex contains a variety of radiological and chemical contaminants of concern (COCs). These COCs are derived from the activation or transmutation of irradiated metals, equipment and piping contaminated with activation and fission products, heavy metals present in structural alloys or used for radiological shielding, and metals used as electrical or thermal conductors and in switches. The locations and estimated total quantities of COCs remaining at the ETR Complex are discussed in the following sections. Estimates provided for the radiological and nonradiological constituents are a "snapshot" of the inventories prior to the deactivation activities (described in Section 2.2.3). Although these activities will reduce the inventories of both of these types of materials, the total inventory amount is used to ensure that the risk evaluation is conservative and bounds the residual contamination remaining after the ETR Complex decommissioning is complete.

2.3.1 Estimated Remaining Engineering Test Reactor Complex Radionuclide Inventory

Several Engineering Design Files (EDFs) document the estimated remaining radionuclide source-term data throughout the ETR Complex. These EDFs are as follows:

- EDF-6133, "ETR Reactor Vessel Source Term and External Dose Rates"
- EDF-6138, "Radiological Characterization of the ETR Complex External Surfaces"
- EDF-6291, "Radiological Characterization of the Engineering Test Reactor (ETR) Complex Internal Surfaces"
- EDF-6304, "ETR Complex Activity vs. Depth"
- EDF-6958, "Engineering Test Reactor Radionuclides and Radionuclide Relative Ratios"
- EDF-7222, "ETR Beryllium Reflector and Vessel Transuranic Inventories."

This EE/CA will become part of the INL Administrative Record. Documentation supporting this EE/CA, such as the above EDFs, will also be included in the Administrative Record.

The source term of the ETR vessel and components was calculated in EDF-6133 using the MicroShield Model Version 6.10, based on dose measurements taken in July 2005 at seven areas within the ETR vessel and on internal surface contamination survey results presented in EDF-6291. Relative ratios of radionuclides in activated metals were estimated based upon ORIGEN2 model simulations of the operation of the ETR, as described in EDF-6958.

The radiological characterization of the external surfaces in the TRA-642, TRA-643, and TRA-644 areas is based upon smear samples collected in July 2005, as described in EDF-6138. The samples were collected from exposed areas throughout the buildings and structures.

The radiological characterization of the ETR Complex's internal surfaces (the surfaces inside piping, equipment, tanks, and the ETR vessel) and a source term for these surfaces are described in EDF-6291. The source-term calculations were based on radiological surveys performed throughout these three buildings on the primary coolant and waste drain piping, and a sample consisting of activated corrosion products collected in September 2005 from the PCS at a heat exchanger low-point drain. The characterization is based upon the following conservative assumptions: (1) the relative ratios between the radionuclides are the same on the internal surfaces as they are in the scale that was sampled and (2) the contamination is uniformly distributed throughout these contaminated systems.

The estimated radionuclide source-term inventory from the TRA-648 building and the inventory from the filter vaults associated with the ETR exhaust air system (TRA-704, TRA-705, and TRA-706) are described in EDF-6304. The source-term data used in the calculations were derived from data in EDF-6958, EDF-6133, EDF-6138, and EDF-6291. Table 2-1 provides a summary of the total estimated radionuclide inventory for the entire ETR Complex. Of the approximately 59,000 total Curies present in the entire ETR Complex, fewer than 2 Ci are dispersed throughout the buildings and structures, and the remainder is contained in the reactor vessel. This residual inventory is found primarily within internal piping surfaces from nickel-63 contamination. However, minor fractions of the residual inventory are ubiquitous on external surfaces throughout the belowgrade components of the ETR Complex. Most of the remaining 2 Ci is being removed with the ongoing deactivation activities. An estimate of remaining nonreactor radioactive nuclides remaining at the end of the deactivation activities would be less than one-tenth (0.1) of a Curie. At the end of institutional controls in the year 2095, this 0.1 Ci would decay to about 0.008 Ci of mostly Ni-63. By comparison, the natural radioactivity in soil is roughly 14 pCi/g (mainly from potassium, thorium, and radium).

Table 2-1. Estimated total inventory of radionuclides in the Engineering Test Reactor Complex (in Ci).

Nuclide	ETR Vessel Inventory EDF-6133 (Ci)	ETR Complex Surfaces: Total ETR Internal Inventory EDF-6291 (Ci)	ETR Complex Surfaces: ETR Vessel Portion of ETR Internal Inventory EDF-6291 (Ci)	ETR Complex Surfaces: External Inventory EDF-6138 (Ci)	Vaults/Tanks Inventory EDF-6304 (Ci)	ETR Complex Total Inventory (Ci)
Ac-227	1.01E-06	—[a]	—	—	—	1.01E-06
Ag-108m	2.42E-01	—	—	1.17E-04	—	2.42E-01
Ag-110m	7.40E-11	—	—	—	—	7.40E-11
Am-241	1.82E-01	1.38E-04	1.68E-06	—	1.44E-05	1.82E-01
Am-243	2.76E-03	—	—	—	—	2.76E-03
Be-10	3.73E-01	—	—	—	—	3.73E-01
C-14	1.33E+01	2.22E-04	2.69E-06	4.84E-04	—	1.33E+01
Ce-144	2.26E-09	—	—	—	—	2.26E-09
Cl-36	1.26E-01	—	—	—	—	1.26E-01
Cm-243	5.04E-04	—	—	—	—	5.04E-04
Cm-244	3.20E-01	—	—	—	—	3.20E-01
Cm-245	6.05E-05	—	—	—	—	6.05E-05
Cm-246	6.68E-05	—	—	—	—	6.68E-05
Cm-247	4.71E-10	—	—	—	—	4.71E-10
Cm-248	8.45E-09	—	—	—	—	8.45E-09
Co-60	1.97E+03	4.03E-01	4.88E-03	7.56E-03	8.69E-04	1.97E+03
Cs-134	2.95E-03	—	—	—	—	2.95E-03
Cs-137	2.71E+00	2.88E-03	3.49E-05	4.10E-02	7.51E-03	2.76E+00
Eu-152	1.82E-01	—	—	—	—	1.82E-01
Eu-154	1.05E+00	—	—	—	—	1.05E+00
Fe-55	6.63E-03	5.47E-01	6.63E-03	—	—	5.47E-01
H-3	3.29E+04	—	—	—	—	3.29E+04

Table 2-1. (continued).

Nuclide	ETR Vessel Inventory EDF-6133 (Ci)	ETR Complex Surfaces: Total ETR Internal Inventory EDF-6291 (Ci)	ETR Complex Surfaces: ETR Vessel Portion of ETR Internal Inventory EDF-6291 (Ci)	ETR Complex Surfaces: External Inventory EDF-6138 (Ci)	Vaults/Tanks Inventory EDF-6304 (Ci)	ETR Complex Total Inventory (Ci)
I-129	4.24E-06	—	—	2.40E-05	—	2.82E-05
Mn-54	3.21E-06	—	—	—	—	3.21E-06
Nb-94	4.83E+00	—	—	—	—	4.83E+00
Ni-59	1.32E+02	1.03E-02	1.25E-04	—	—	1.32E+02
Ni-63	2.42E+04	9.82E-01	1.19E-02	4.62E-03	—	2.42E+04
Np-237	2.15E-06	—	—	4.98E-07	—	2.65E-06
Pa-231	1.48E-06	—	—	—	—	1.48E-06
Pb-210	6.89E-11	—	—	—	—	6.89E-11
Pu-238	8.36E-02	1.59E-04	1.93E-06	6.24E-06	3.60E-06	8.38E-02
Pu-239	1.82E-02	2.47E-04	2.99E-06	7.90E-06	2.97E-05	1.85E-02
Pu-240	2.23E-02	—	—	—	—	2.23E-02
Pu-241	1.82E+00	—	—	—	4.18E-04	1.82E+00
Pu-242	2.84E-04	—	—	—	—	2.84E-04
Pu-244	2.67E-10	—	—	—	—	2.67E-10
Ra-226	1.11E-10	—	—	—	—	1.11E-10
Ru-106	3.13E-07	—	—	—	—	3.13E-07
Sb-125	6.60E-03	—	—	—	—	6.60E-03
Sr-90	8.45E-01	2.70E-03	3.27E-05	2.92E-03	5.21E-04	8.51E-01
Tc-99	6.34E-03	—	—	3.70E-05	—	6.38E-03
Th-228	1.79E-04	—	—	—	—	1.79E-04
Th-229	1.20E-06	—	—	—	—	1.20E-06
Th-230	1.17E-08	—	—	—	—	1.17E-08
Th-232	2.05E-06	—	—	—	—	2.05E-06
U-232	1.73E-04	—	—	—	—	1.73E-04
U-233	3.41E-04	2.42E-05	2.94E-07	4.98E-07	1.20E-06	3.67E-04
U-234	3.07E-05	—	—	4.98E-07	—	3.12E-05
U-235	2.62E-07	6.48E-07	7.85E-09	—	1.47E-09	9.04E-07
U-236	7.23E-07	—	—	—	—	7.23E-07
U-238	8.53E-06	—	—	—	2.67E-06	1.12E-05
Zn-65	1.71E-10	—	—	—	—	1.71E-10
					Total	5.91E+04

Note: Shaded rows indicate the primary radiological inventory contributors.

a. — = nuclide not present

EDF = Engineering Design File.
ETR = Engineering Test Reactor.

EDF-6958 provides the basis for the radiological characterization of the ETR Complex by documenting the radionuclides and the scaling factors between the radionuclides of the activated metals inside the ETR vessel. These radionuclides and scaling factors are then used in Microshield models to estimate the source term values (activity) of the reactor and activated components based on dose rate measurements.

2.3.1.1 ETR Vessel Transuranic Inventory. The ETR vessel was constructed with a beryllium reflector which surrounded the core to reflect neutrons back into the core area. The reflector is constructed with 10 slabs of beryllium metal stacked on top of each other to form each of the four sides. Each slab measures approximately 4.5 in. wide by 36 in. long and is 4 in. thick. These four stacks surrounded the core, resulting in a total of 40 slabs. The slabs are fastened in place to form an integral component of the reactor core.

In order to determine if the ETR vessel meets disposal criteria of the disposal facilities, the transuranic inventory of the vessel had to be determined. Beryllium ore contains small amounts of naturally occurring uranium isotopes when it is mined. This uranium, when exposed to a neutron flux, as occurred during operation of the ETR reactor, transmutates into transuranic isotopes. A transuranic isotope is of concern due to the long half-life of the isotope (greater than 20 years). To determine the transuranic content of the beryllium in the ETR vessel, a sample was obtained in April 2006 from the top of the ETR reflector plug and was sent to an off-Site laboratory for analysis. Based partly on measured data obtained from that sample and on computer code calculations that extrapolate these measured results to the entire reflector, a total transuranic concentration of the ungrouted ETR vessel as a waste package was determined to be 1.99 nCi/g (potential error of ±20%). The modeling process and calculations for determining the ETR vessel transuranic inventory are found in EDF-7222.

Determination of the transuranic isotope concentration is important in determining if the ETR vessel waste package meets the waste disposal criteria for the various disposal facilities evaluated in this EE/CA. For example, the Idaho CERCLA Disposal Facility (ICDF) activity limit for disposal of transuranic isotopes is 10 nCi/g; the 1.99 nCi/g in the ETR vessel is well below this activity limit.

2.3.2 Estimated Remaining Engineering Test Reactor Complex Nonradiological Inventory

As discussed in Section 2.2.3 “Deactivation Activities,” removal of liquids, items that could be considered HWMA/RCRA hazardous waste, asbestos, and chlorofluorocarbons is expected to be complete when the ETR Complex reaches its final end state, as determined by the NTCRA process. The remaining nonradiological COCs expected to remain in the ETR Complex at its end state consist of inert material such as heavy metals present in structural materials, piping, or electrical components.

For purposes of this EE/CA, an estimate of the inventory quantities of these nonradiological COCs is necessary to perform risk analyses and to predict the migration potential of these metals to a future source of drinking water. The nonradiological inventory is described in EDF-6225, “Engineering Test Reactor Complex Chemical Constituent Source Term.” Since this inventory is intended only for risk assessment purposes and only the no action alternative considers leaving the abovegrade superstructure of the ETR Complex buildings at the present location, only those COCs (metals) associated with the ETR vessel and belowgrade portions of the ETR Complex were included for evaluation in the estimated inventory. Table 2-2 shows the estimated chemical constituent quantities in the ETR Complex (assuming the reactor vessel is left in place).

Table 2-2. Estimated chemical constituents in the materials of construction in the ETR Complex (kg).

Chemical Constituent	Location(s)	Use/Form	Quantity (kg)
Aluminum	ETR vessel	ETR vessel components	3,340
Antimony	Concrete walls and floors	Alloy used in concrete wall lag-shield anchors	0.6
Barium (and compounds)	High-density concrete used in cubicle walls	Additive for heavy concrete used in nuclear shielding (cubicle walls), paint pigment	101,810
Beryllium (and compounds)	ETR vessel	Neutron reflector in the pressure vessel	700
Boron	Shielding for ion-chamber drive assembly	Shielding in the ion-chamber drive assembly, added to concrete	0.5
Chromium	Piping and other operations components throughout the ETR Complex	Piping, vessels, and other components constructed of stainless steel	35,420
Copper (and compounds)	ETR Complex	Wiring, tubing, rotors, bearings, brass and bronze components, and electrical equipment	36,840
Lead	Wall and floor anchors, piping	Small amounts of inaccessible lead wool around piping penetrations, alloy of concrete wall lag-shield anchors, pipe packing, and brass alloy	40
Manganese (and compounds)	Piping and other operations components throughout the ETR Complex	Metal alloy found in piping, vessels, and other components constructed of stainless steel	7,670
Nickel	Piping and other operations components throughout the ETR Complex, gray control rod poison	Metal alloy found in piping, vessels, and other components constructed of stainless steel	19,610
Silver (and compounds)	Electrical components	Small amounts of inaccessible electrical contacts	40
Tin	ETR Complex	Alloy of bronze (used in gauges, bearings, and flow indicators)	80
Uranium	ETR Complex	Metallic uranium calculated from the activities of the uranium isotopes	0.0338
Zinc	ETR Complex	Significant alloy of brass	460

ETR = Engineering Test Reactor.

2.4 Risk Assessment

Risk analyses were prepared that utilized the results of the radiological and nonradiological characterization evaluations, as described in EDF-7243, "Streamlined Risk Assessment for the D&D of the ETR Reactor Facilities," and EDF-5142, "Groundwater Pathway Risk Assessment for the Engineering Test Reactor Complex Closure." These risk assessments were prepared to assist in the evaluation of alternatives. Section 2.4.1 discusses the methodology and summarizes the results of the soil pathways risk analysis. Section 2.4.2 describes the results of the groundwater risk analysis.

2.4.1 Soil Pathways Risk Analysis for Engineering Test Reactor Complex Contaminants of Concern

The primary objective of the soil pathways' streamlined risk assessment is to determine whether leaving the currently estimated contaminant inventories in place would be acceptable in terms of risk to a hypothetical future resident, as described by the remedial action objectives (RAOs) for the ROD (DOE-ID 1997) and the Explanation of Significant Differences (DOE-ID 2000). The soil pathways risk analysis is described in EDF-7243. This risk assessment evaluated two scenarios; both assumed that the abovegrade portions of the ETR building were removed. One scenario is consistent with Alternative 2 and assumes the ETR vessel is not removed, and everything else below grade is left in place. The other scenario assumes the ETR vessel is removed, and everything else below grade is left in place. This scenario is consistent with Alternatives 3 and 4. The alternatives are fully described in Section 4 of this EE/CA.

2.4.1.1 Soil Pathways Initial Contaminant of Concern Screening. Radionuclides were initially screened using EPA's conservative *Soil Screening Guidance for Radionuclides: User's Guide* (EPA 2000a). Soil screening levels (SSLs) were derived based on a predicted 1×10^{-6} excess cancer risk using equations in the guidance for (1) soil ingestion, (2) ingestion of homegrown produce grown in contaminated soil, (3) inhalation of windblown dust, and (4) external exposure. The lowest SSL for each radionuclide was compared to soil concentrations calculated using the total inventories present in the ETR vessel and below grade as described in EDF-6304. The radionuclide soil concentrations' source term for the screening assumes that the radionuclide COCs in the 10 ft below ground surface inventory remaining within the ETR Complex are dispersed through a volume of soil equal to the total of the ETR Complex buildings and structures footprints (45,759 ft^2) to a depth of 10 ft below the ground surface.
Any radionuclide exceeding the SSLs was retained for all alternatives.

Nonradiological contaminants were screened using EPA's *Soil Screening Guidance: User's Guide* (EPA 1996). Only the pathways of soil ingestion and inhalation for both carcinogens and noncarcinogens are considered in this screening. None of the nonradiological constituents exceeded the SSL; thus, additional evaluation is unnecessary. Eleven radionuclides exceeded the SSLs and are carried forward for more detailed risk analysis. Results of the screening are presented in Tables 2-3 and 2-4.

Table 2-3. Radionuclide soil concentrations compared to soil screening levels (2005 inventories).

Radionuclide COC	ETR Alternative 2 (Vessel in Place) Soil Concentration (pCi/g)	ETR Alternatives 3 and 4 (Vessel Removed) Soil Concentration (pCi/g)	Lowest SSL All Scenarios (pCi/g)	Exceeds SSL? Alternative 2 (Yes/No)	Exceeds SSL? Alternatives 3 and 4 (Yes/No)
Ac-227	4.44E-07	0.00E+00	2.08E+00	No	No
Ag-108m	1.07E-01	4.05E-04	1.55E-02	Yes	No
Ag-110m	3.24E-11	0.00E+00	8.58E-03	No	No
Am-241	8.00E-02	5.91E-04	3.66E+00	No	No
Am-243	1.21E-03	0.00E+00	1.18E+00	No	No
Be-10	1.64E-01	0.00E+00	3.45E+01	No	No
C-14	5.80E+00	1.44E-03	1.28E-01	Yes	No
Ce-144	9.93E-10	0.00E+00	2.22E+00	No	No
Cl-36	5.54E-02	0.00E+00	1.59E-02	Yes	No
Cm-243	2.21E-04	0.00E+00	2.66E-01	No	No
Cm-244	1.41E-01	0.00E+00	4.38E+00	No	No
Cm-245	2.65E-05	0.00E+00	4.69E-01	No	No
Cm-246	2.93E-05	0.00E+00	3.74E+00	No	No
Cm-247	2.06E-10	0.00E+00	8.52E-02	No	No
Cm-248	3.70E-09	0.00E+00	3.26E+03	No	No
Co-60	8.68E+02	1.69E+00	9.00E-03	Yes	Yes
Cs-134	1.29E-03	0.00E+00	1.57E-02	No	No
Cs-137	1.28E+00	8.68E-02	4.38E-02	Yes	Yes
Eu-152	8.00E-02	0.00E+00	2.11E-02	Yes	No
Eu-154	4.58E-01	0.00E+00	1.91E-02	Yes	No
Fe-55	7.95E-01	2.29E+00	3.80E+02	No	No
H-3	1.44E+04	0.00E+00	4.50E+00	Yes	No
I-129	4.21E-05	3.98E-05	2.19E-01	No	No
Mn-54	1.41E-06	0.00E+00	2.87E-02	No	No
Nb-94	2.12E+00	0.00E+00	1.53E-02	Yes	No
Ni-59	5.80E+01	4.31E-02	7.24E+01	Yes	No
Ni-63	1.06E+04	4.11E+00	2.96E+01	Yes	No
Np-237	9.41E-07	0.00E+00	8.49E-01	No	No
Pa-231	6.48E-07	0.00E+00	6.23E-01	No	No
Pb-210	3.02E-11	0.00E+00	1.19E-01	No	No
Pu-238	3.74E-02	6.80E-04	2.92E+00	No	No
Pu-239	9.04E-03	1.07E-03	2.88E+00	No	No
Pu-240	9.78E-03	0.00E+00	2.87E+00	No	No
Pu-241	7.95E-01	3.94E-04	2.41E+02	No	No
Pu-242	1.25E-04	0.00E+00	3.02E+00	No	No
Pu-244	1.17E-10	0.00E+00	2.70E+00	No	No
Ra-226	4.88E-11	0.00E+00	6.85E-02	No	No
Ru-106	1.37E-07	0.00E+00	1.15E-01	No	No

Table 2-3. (continued).

Radionuclide COC	ETR Alternative 2 (Vessel in Place) Soil Concentration (pCi/g)	ETR Alternatives 3 and 4 (Vessel Removed) Soil Concentration (pCi/g)	Lowest SSL All Scenarios (pCi/g)	Exceeds SSL? Alternative 2 (Yes/No)	Exceeds SSL? Alternatives 3 and 4 (Yes/No)
Sb-125	2.89E-03	0.00E+00	6.16E-02	No	No
Sr-90	3.83E-01	1.21E-02	4.92E-02	Yes	No
Tc-99	2.84E-03	6.12E-05	7.04E-02	No	No
Th-228	7.84E-05	0.00E+00	2.75E+00	No	No
Th-229	5.28E-07	0.00E+00	4.96E-01	No	No
Th-230	5.14E-09	0.00E+00	6.67E+00	No	No
Th-232	8.99E-07	0.00E+00	5.97E+00	No	No
U-232	7.58E-05	0.00E+00	1.46E+00	No	No
U-233	2.56E-04	1.04E-04	5.81E+00	No	No
U-234	1.35E-05	0.00E+00	5.02E+00	No	No
U-235	2.99E-06	2.79E-06	2.15E-01	No	No
U-236	3.17E-07	0.00E+00	5.33E+00	No	No
U-238	6.27E-06	2.51E-06	6.50E+00	No	No
Zn-65	7.48E-11	0.00E+00	3.97E-02	No	No

Note: Shading indicates a COC that exceeds the SSL.

COC = contaminant of concern.
ETR = Engineering Test Reactor.
SSL = soil screening level.

Table 2-4. Nonradiological soil concentrations compared to soil screening levels.

Nonradiological COC	ETR Alt. 2 Soil Concentration (mg/kg)	ETR Alt. 3 and 4 Soil Concentration (mg/kg)	Lowest SSL (mg/kg)	Exceeds SSL? (Yes/No)
Aluminum	1.75E+02	0	NA[a]	No
Antimony and compounds	3.14E-02	3.14E-02	3.13E+01	No
Boron	2.61E-02	2.61E-02	1.56E+04	No
Chromium	1.85E+03	1.85E+03	1.17E+05	No
Copper and compounds	1.93E+03	1.93E+03	NA	No
Lead	2.09E+00	2.09E+00	NA	No
Manganese and compounds	4.01E+02	4.01E+02	1.10E+04	No
Nickel (soluble salts)	1.03E+03	1.03E+03	1.56E+03	No
Silver and compounds	2.09E+00	2.09E+00	3.91E+02	No
Tin (inorganic)	4.18E+00	4.18E+00	NA	No
Zinc	3.87E+01	3.87E+01	2.35E+04	No

a. NA = There are no risk factors available for these metals; however, for lead, the EPA has established an action level for lead contamination in bare soil of 400 ppm (mg/kg).

COC = contaminant of concern.
EPA = U.S. Environmental Protection Agency.
ETR = Engineering Test Reactor.
SSL = soil screening level.

2.4.1.2 Methodology of Soil Pathways Analysis. Risks from COCs that might be left in place after a removal action were evaluated by considering a worst-case contaminant source term and exposure scenario. The risk scenarios assume that any COCs remaining are mixed uniformly in the top 10 ft (3.05 m) of soil and are available to an intruder in the year 2095. The risk scenarios and timeline until the potential for residential use may be considered (after 2095) are derived from the risk management scenarios utilized in the ROD (DOE-ID 1997). The exposure scenario used for Alternative 2 assessments (ETR vessel left in place) assumes that the remaining contamination will be grouted in place for 90 years and that the COCs will be instantaneously released from the grout at the end of this period. The scenario also assumes that a hypothetical future resident will build a house at the site of the removal action as soon as the grout fails, 10 ft of contaminated material will be excavated while building a basement, and contamination will be spread across the surface of the housing site. Finally, the scenario assumes a person will live at the site for 30 years, including 6 years of childhood, while being exposed to contamination through soil ingestion, fugitive dust inhalation, external radiation exposure, and ingestion of contaminated fruits and vegetables grown around the house. Risks were evaluated for:

- Alternative 2: The ETR vessel is assumed to be grouted in place and the reactor buildings removed to ground level. The contaminant inventory in the 10 ft below ground surface interval of the vessel and reactor buildings belowgrade areas is used in the risk assessment.

- Alternatives 3 and 4: The ETR vessel, and therefore the vessel's contaminant inventory, is removed and disposed of elsewhere, and the reactor building is removed to ground level. For Alternatives 3 and 4, the only contaminant inventory remaining is in the belowgrade portions of the ETR Complex.

Standard EPA risk assessment equations were used to assess risk from radiological (Table 2-3) and nonradiological contaminants (Table 2-4). For radionuclides, these equations calculate intakes via ingestion of soil and homegrown produce, inhalation of resuspended soil, and external exposure to ionizing radiation. Exposures are then combined with risk factors (toxicity data) to assess overall risk. The equations utilized and the methodology are further described in EDF-7243.

2.4.1.3 Summary of the Results of the Soil Pathways Risk Analysis. The results of the soil pathways carcinogenic risk analysis for the ETR Complex for Alternative 2 are shown in Table 2-5 and for Alternatives 3 and 4 in Table 2-6. Under all alternatives, EDF-7243 calculates the soil pathways noncarcinogenic risk hazard index as less than 1.0. If the ETR vessel remains in the final end state (Alternative 2), the acceptable carcinogenic risk range of 1×10^{-4} is exceeded (2×10^{-4}) for the sum of all exposure pathways with Nb-94 representing the largest contribution to the risk (1×10^{-4}).

This soil pathway risk analysis included contamination in piping and components throughout the ETR complex that were removed during the recent deactivation activities. These components and piping with a potential for containing contamination in the 10-ft interval have been mostly removed; however, the contaminant concentration before removal was used in the risk assessment. If the vessel is removed, there is high confidence that isolated concentrations that exceed the SSLs would not remain in this 10-ft interval. The vast majority of the remaining contamination (.06 Ci) is on surfaces in areas well below 10 ft below ground surface and is widely and somewhat uniformly distributed over the remaining buildings and structures.

Table 2-5. Risk by radionuclide and pathway for Engineering Test Reactor Alternative 2 in the year 2095.

Radionuclide	Soil Ingestion	Inhalation	External Exposure	Produce Ingestion	SUM
Ag-108m	1.E-09	1.E-13	3.E-06	1.E-08	3.E-06
C-14	2.E-08	5.E-12	4.E-10	1.E-05	1.E-05
Cl-36	5.E-10	2.E-13	9.E-10	1.E-06	1.E-06
Co-60	2.E-15	2.E-19	5.E-12	2.E-14	5.E-12
Cs-137+d[a]	1.E-09	3.E-14	5.E-07	6.E-09	5.E-07
Eu-152	2.E-13	8.E-17	4.E-10	3.E-14	4.E-10
Eu-154	8.E-15	3.E-18	1.E-11	2.E-15	1.E-11
H-3	2.E-10	1.E-14	0.E+00	8.E-08	8.E-08
Nb-94	5.E-08	9.E-12	1.E-04	5.E-08	1.E-04
Ni-63	7.E-06	6.E-10	0.E+00	3.E-05	4.E-05
Sr-90+d[a]	1.E-09	7.E-14	9.E-10	3.E-08	3.E-08
				Total	**2.E-04**

a. "d" indicates daughter product.

Table 2-6. Risk by radionuclide and pathway for Engineering Test Reactor Alternatives 3 and 4 in the year 2095.

Radionuclide	Soil Ingestion Risk	Inhalation Risk	External Exposure Risk	Food Ingestion Risk	SUM
Ag-108m	6.E-12	8.E-16	2.E-08	8.E-11	2.E-08
C-14	5.E-12	1.E-15	1.E-13	3E-09	5.E-12
Co-60	6.E-13	5.E-17	1.E-09	4.E-12	1.E-09
Cs-137+d[a]	6.E-10	2.E-14	3.E-07	3.E-09	3.E-07
Ni-63	5.E-09	4.E-13	0.E+00	2.E-08	3.E-08
Sr-90+d[a]	3.E-10	2.E-14	2.E-10	8.E-09	9.E-09
				Total	**3.E-07**

a. "d" indicates daughter product.

This analysis propagates conservatism throughout the risk assessment steps. It assumes that the radionuclides present within activated metal components in the ETR vessel corrode and become mixed with soil after 90 years, a hypothetical future resident builds a home and resides at the location of the former RTC facilities, and the receptor consumes produce grown in the contaminated area. Under the Alternatives 3 and 4 scenarios, the ETR vessel is removed and shipped to a disposal facility; conservatism is built in to the evaluation by using a source term of approximately 2 Ci of activity rather than the estimated total inventory remaining after decommissioning and demolition (D&D) activities of less than one-tenth (0.1) Ci total activity. The carcinogenic risk (3×10^{-7}) from the remaining radionuclides at the ETR Complex is an acceptable risk because it is less than acceptable risk range of 1×10^{-6} to 1×10^{-4}.

2.4.2 Groundwater Pathway Risk Assessment Contaminants of Concern

The primary objective of the groundwater pathway streamlined risk assessment is to show whether leaving the currently estimated contaminant inventories in place would be acceptable in terms of groundwater protection. The groundwater risk analysis is described in EDF-5142, which contains detailed discussions of the approach and the results. The analysis assumed that the primary structure above grade will be removed, the ETR vessel will not be removed, and everything else below grade will be left in place. This methodology evaluates the ETR Complex's end state conservatively by assuming that the ETR vessel is left in place and belowgrade structures will be stabilized by filling with native soils for the screening analysis and grout for the risk assessment of the COCs identified via screening. The radionuclide and nonradiological source terms utilized for this analysis are those previously discussed in Section 2.3.

2.4.2.1 Contaminant Screening Approach. Contaminant transport evaluation and risk assessment were performed through a series of two screening phases, followed by a more detailed risk assessment. Each screening phase begins with conservative assumptions. The conservatism of the assumptions is lessened through each screening phase. The two screening analysis phases are as follows:

- Phase 1 screening is only used for radionuclides. It uses screening factors developed by the National Council on Radiation Protection (NCRP) (NCRP 1996) together with the estimated contaminant inventory. This screening approach has been used in a variety of past INL Site studies, including the EE/CA for CPP-603 (DOE-NE-ID 2004, EDF-4488) and the ICDF performance assessment (DOE-ID 2003).

- Phase 2 screening used a simple and conservative application of the GWSCREEN (Rood 2003) model to calculate a screening dose, risk, or concentration based on the contaminant radionuclide or nonradiological inventory. The GWSCREEN application considers dispersion and unsaturated transit time, whereas the NCRP does not. The Phase 2 screening application of GWSCREEN is based on the Track 2 screening approach used in the CERCLA process at the INL (DOE-ID 1994). The Track 2 screening approach is documented in *Track 2 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL* (DOE-ID 1994). The methodology was originally developed to perform conservative analysis on low-probability CERCLA sites with the goal to systematically eliminate no action sites from further evaluation. Since that time the methodology has regularly been used for contaminant screening at the INL.

Contaminants not screened out are defined as the COCs. For the COCs' risk assessment, some of the more stringent, conservative assumptions used in the Phase 2 screening were relaxed. However, the final analysis is still conservative in the sense that it is based, in large part, on the conservative assumptions of a Track 2 analysis, changing some of the parameters to more accurately represent the ETR source term and flow, and transport system. Results of the screening are presented in this section. Detailed descriptions of the approach, analysis, and tables of results are presented in EDF-5142.

2.4.2.2 Phase 1 Screening for Radionuclides. Nuclides with an NCRP screening dose of less than 1 mrem (1×10^{-5} Sv) were removed from further consideration. Of the 52 nuclides for which inventories are estimated, 24 were screened in Phase 1, leaving 28 nuclides for further evaluation. These 28 nuclides were retained for the Phase 2 evaluation.

2.4.2.3 Phase 2 Screening. Phase 2 screening used a conservative implementation of the groundwater-screening model GWSCREEN Version 2.5 (Rood 2003) to calculate groundwater concentrations' ingestion doses and risk for nuclides that were not screened in Phase 1. For the 15 nonradiological constituents in the inventory, the peak concentration was calculated for comparison

with the maximum contaminant level (MCL) or a related limiting value. The GWSCREEN model was developed to address CERCLA sites at the INL. The code, coupled with a set of default parameter values identified in the CERCLA Track 2 risk assessment process (DOE-ID 1994), provides conservative estimates of groundwater concentrations and the related ingestion doses and risks at the INL Site. The contaminants are screened based on the predicted peak dose and risk for radionuclides and the predicted peak concentration for nonradiological constituents.

2.4.2.3.1 Phase 2 Radionuclide Screening Results—Using the criteria that the predicted peak dose is greater than 0.4 mrem/yr and/or the predicted peak risk is greater than 10^{-6}, of the 28 nuclides remaining from Phase 2 screening, only C-14, Cl-36, H-3, Ni-59, and Pu-239 were defined as COCs and evaluated for risk, and the remaining nuclides were eliminated from further consideration. Note that this assessment used the Track 2 screening assumptions and K_d values for soils. Any closure action (such as grouting) would tend to decrease the contaminants' mobility and further decrease the predicted dose and risk in the aquifer. In addition, any soil cover that decreases the infiltration rate from 10 cm/yr (Track 2 screening value) to 1 cm/yr (undisturbed INL Site sediment estimate) would decrease the predicted peak concentration by an order of magnitude.

2.4.2.3.2 Phase 2 Nonradiological Screening Results—As with the radionuclide Phase 2 evaluation, the infiltration rate is set at 10 cm/yr, which is a factor of 10 times the undisturbed soil infiltration assumed for INL Site soils.

Using one-tenth the MCL (or related water concentration) as a screening criteria, about half of the nonradiological constituents were screened from further consideration. The nonradiological constituents remaining after the screen are barium, beryllium, chromium, copper, manganese, and nickel. Of these, only barium, beryllium, and chromium have MCLs assigned. The others have nonenforceable guidelines (copper has an action level, manganese has a secondary MCL, and the nickel MCL has been remanded). The only nonradiological constituents with a screening level predicted peak aquifer concentration greater than the MCL is chromium. Note again that this assessment basically used the Track 2 screening assumptions and K_d values for soils. Any closure action (such as grouting) would tend to decrease the mobility of the screened contaminants and further decrease the predicted dose and risk in the aquifer. Chromium is an exception to this—as the pH increases (as would occur with grouting), the predominant valence state of chromium changes from trivalent (relatively immobile) to hexavalent (relatively mobile) chromium. For this analysis, a relatively mobile form of chromium is assumed for the source, vadose zone, and aquifer, so the fact that chromium does not necessarily become less mobile when grouted does not affect the results or conclusions. In addition, any soil cover that decreases the infiltration rate from 10 cm/yr (Track 2 screening value) to 1 cm/yr (undisturbed INL Site sediment estimate) would decrease the predicted peak concentration by an order of magnitude.

2.4.2.4 Groundwater Risk Assessment. After screening, five radionuclides and six nonradiological constituents require further analysis and are defined as the COCs. The COCs are C-14, Cl-36, H-3, Ni-59, Pu-239, barium, beryllium, chromium, copper, manganese, and nickel. A more detailed and site-specific risk analysis was conducted for these COCs.

The risk assessment results were calculated in two stages. The first stage ignores the fact that the contaminants are largely a part of the beryllium and stainless steel within the ETR. For all COCs that have a predicted risk that is not a significant contributor to the cumulative groundwater risk or MCL, no further calculations were performed. For COCs that are significant contributors to cumulative risk or the MCL, the peak aquifer concentrations and risks were recalculated, including corrosion in the source release model.

The radionuclide results are summarized in Table 2-7. Results are shown for both with and without the corrosion model (for C-14). If the COCs are assumed to be mixed in the backfilled soils in the ETR facility rather than contained in the stainless steel and beryllium, the predicted peak risk ranged from 8.1×10^{-6} for C-14 to 5.1×10^{-12} for Pu-239. A risk of $> 1 \times 10^{-6}$ was used to define a significant cumulative risk contributor. Only C-14 was predicted to have a total groundwater pathway risk of greater than 1×10^{-6}. Therefore, the C-14 was resimulated including corrosion in the release model. The predicted peak C-14 risk is 1.6×10^{-6} when corrosion is included, which is about five times less than the C-14 risk calculated without including the corrosion mechanism and about 62 times smaller than the 1×10^{-4} risk standard. The predicted peak risk for all radionuclides is well below the 1×10^{-4} standard. The maximum cumulative risk is 8.2×10^{-6} if corrosion is not considered and 1.6×10^{-6} if corrosion is considered. C-14 dominates the groundwater risk for approximately the first 40,000 years, then Ni-59 is the dominant risk.

Table 2-7. ETR radionuclide groundwater risk assessment, assuming the contaminants are immediately available for release.

		Without Corrosion Model				With Corrosion Model	
Nuclide	Progeny	Date of Peak Time (yr)	Peak Concentration (pCi/L)	Peak Decay Chain Groundwater Pathway Risk	Total Groundwater Pathway Risk by Nuclide	Peak Concentration (pCi/L)	Total Groundwater Pathway Risk by Nuclide
C-14	—	2,853	2.48E+02	8.1E-06	8.1E-06	5.06E+01	1.6E-06
Cl-36	—	2,587	3.91E+00	2.7E-07	2.7E-07	NA	NA
H-3	—	2,135	7.84E+00	8.1E-09	8.1E-09	NA	NA
Ni-59	—	185,130	1.05E+00	6.1E-09	6.1E-09	NA	NA
Pu-239	—	145,260	1.75E-06	5.0E-12	5.1E-12	NA	NA
	U-235	a	6.99E-08	1.0E-13	a	NA	NA
	Pa-231	a	8.13E-10	3.0E-15	a	NA	NA
	Ac-227	a	9.94E-10	4.2E-15	a	NA	NA
			Maximum Cumulative Risk		8.2E-06		1.6E-06[b]

NA = Did not exceed risk threshold.

a. Progeny are assumed to travel with the parent.
b. The cumulative risk with corrosion is the C-14 risk with corrosion plus the risk from Cl-36, H-3, Ni-59, and Pu-239 without corrosion.

The nonradiological results are summarized in Table 2-8. Results are shown for both with and without the corrosion model (for chromium). When no corrosion is considered, the predicted peak fraction of the MCL ranged from 1.6 for chromium to 0.0043 for beryllium. Only the peak predicted chromium concentration is greater than its MCL. The next largest fraction of the MCL is 0.019 (or 1.9%) for manganese. Chromium is the only nonradiological COC that would significantly contribute to the cumulative MCL. The chromium was resimulated, including the corrosion mechanism. Based on the corrosion model, the predicted peak chromium concentration was 0.016 (the MCL is 0.1) and the fraction of the chromium peak concentration to the MCL is 0.16. The maximum cumulative fraction of the COC concentrations to their MCLs is 1.57 if corrosion is not considered and 0.17 if corrosion is considered.

Table 2-8. ETR nonradiological groundwater risk assessment, assuming the contaminants are immediately available for release.

Contaminant	K_d (mL/g)	MCL or Related Concentration Limit (mg/L)	Years to Peak Concentration	Without Corrosion Model		With Corrosion Model [a]	
				Predicted Peak Concentration (mg/L)	Fraction—Peak Concentration to the MCL (mg/L)	Predicted Peak Concentration (mg/L)	Fraction—Peak Concentration to the MCL (mg/L)
Barium (MCL)	50	2	146,990	1.3E-02	0.0063	NA	NA
Beryllium (MCL)	250	0.004	724,610	1.7E-05	0.0043	NA	NA
Chromium (MCL total)	1.2	0.1	6,053	1.6E-01	1.57	1.58E-02	0.158
Copper (action level)	20	1.3	60,349	1.1E-02	0.0087	NA	NA
Manganese (secondary MCL)	50	0.05	146,990	9.5E-04	0.019	NA	NA
Nickel (remanded MCL)	100	0.1	291,400	1.2E-03	0.012	NA	NA
Maximum Cumulative Fraction to the MCL					1.57	NA	0.169[b]

a. With the corrosion model, the constant chromium flux basically results in a constant flux to the aquifer and concentration in the aquifer from 10,000 years to 60,000 years.
b. The cumulative fraction with corrosion is the chromium fraction with corrosion plus the fraction of the other metals without corrosion.

Action level = Lead is regulated by a treatment technique that requires systems to control the corrosiveness of their water.
EPA = Environmental Protection Agency
MCL = Maximum contaminant level as set by the EPA
MCLG = MCL goal as set by the EPA—nonenforceable guideline. This is protective of adverse human health effects and allows an adequate margin of safety.
NA = Did not exceed risk threshold.Secondary MCL = As set by the EPA—nonenforceable guidelines. Regulate contaminants that may cause cosmetic or esthetic effects.
PRG = Preliminary remediation goal as defined by EPA's Region 9 office. Nonenforceable, generic standard for evaluating and cleaning up contaminated sites.
Remanded MCL = The MCL and MCLG for nickel were remanded on February 9, 1995. This means that there is currently no EPA legal limit on the amount of nickel in drinking water. The remanded MCL was 0.1 mg/L; therefore, that value was used for this screening.

2.4.3 Conclusions from Soil Pathways and Groundwater Risk Assessments

The performance criteria (acceptable risk) for the soil exposure pathways are to inhibit direct exposure to radionuclide COCs that would result in a total excess cancer risk greater than 1×10^{-4} for current and future workers and future residents. In addition, the soil exposure pathways must inhibit ingestion of radionuclide and nonradiological COCs by ingestion (including ingestion of homegrown produce from a hypothetical future garden located within the ETR Complex footprint) that would result in a total excess cancer risk greater than 1×10^{-4} or a hazard index of 1.0 or greater for current and future workers and future residents.

Based on the results of these risk assessments, if the ETR vessel is removed, leaving the remaining source inventory in place results in average soil concentrations and predicted groundwater concentrations that meet the required performance criteria. If the ETR vessel is not removed, the sum of the calculated risks exceeds the performance criteria of 1×10^{-4} because of an estimated total excess carcinogenic risk of 2×10^{-4} to a hypothetical future resident. The hazard index is less than 1 under either scenario.

The performance criteria for groundwater are to prevent migration of contaminants from the ETR Complex that would cause the SRPA to exceed a cumulative carcinogenic risk level of 1×10^{-4} or

applicable State of Idaho groundwater quality standards (MCLs) in 2095 and beyond. The maximum predicted cumulative groundwater risk is 1.6×10^{-6} or one sixty-second of the performance limit of 1×10^{-4} for all radionuclides. For nonradiological constituents, the maximum predicted cumulative groundwater concentration fraction of the MCL is 0.17 or one-sixth the MCL performance limit of 1.

From a cumulative risk standpoint, this streamlined risk assessment demonstrates that leaving less than 2 Ci of the COCs in place in the ETR substructure would result in an insignificant contribution to the cumulative groundwater risk at OU 2-13. However, if the ETR vessel is not removed and institutional controls are not established, the activation products within the ETR vessel could contribute to the overall carcinogenic risk to a hypothetical future resident at OU 2-13 via the soil ingestion pathway. If the ETR vessel is removed and shipped to a disposal facility outside of OU 2-13, the excess cancer risk from all radionuclides within the footprint of the ETR Complex is less than an excess cancer risk greater than 1×10^{-4} or a hazard index of 1.0 or greater for current and future workers and future residents. The concentrations of contaminants predicted for the future in the aquifer—as a result of leaving ETR Complex contaminants in place—are orders of magnitude below the risk-based concentrations corresponding to the RAOs defined in the ROD (DOE-ID 1997) and the Explanation of Significant Differences (DOE-ID 2000).

Removal of material proposed under the decommissioning of the ETR Complex would achieve a significant reduction in the amount of waste left remaining in the RTC area. Removal of the ETR Complex buildings and structure's superstructure and the ETR vessel would reduce the total curies currently present in the ETR Complex from over 59,000 Ci (primarily attributed to tritium and nickel-63 in the ETR vessel) to less than 2 total Ci (primarily within internal surfaces resulting from nickel-63 and tritium) and would reduce the possibility for future spread of contamination. These actions supplement the work already performed under previous activities such as the deactivation activities where other radioactive and hazardous substances were removed from the ETR Complex.

2.4.4 Soil Contamination under the Engineering Test Reactor Complex

Based on records reviewed, potential release sites below the ETR Complex indicate no known significant contaminant releases besides those that are currently being tracked by the INL CERCLA program (i.e., TRA-57 Diesel Line Leak). Potential release sites include locations where past releases of waste constituents—primarily radionuclides—are possible, because the concrete structure is built directly on basalt bedrock and contained a sump, which was used to receive, accumulate, and/or store radioactive waste. These include the hot waste pit, warm waste pit (and warm waste sump), and rod drive access room sump, all located within the ETR building. Potential liquid releases to these basement areas that could have found their way to the environment through cracks or fissures in the concrete construction would be impossible to quantify, even if sampling or screening evidence of contamination below the concrete slab could be obtained.

Based on the available information and risk assessment analysis, these areas are not available to surface pathway receptors due to their depth, and there is no evidence that sufficient releases could have occurred under the complex to result in an incremental increase to the groundwater (concentration or risk). Under the *Groundwater Monitoring Plan for the Test Reactor Area Operable Unit 2-13* (DOE-ID 2004a), perched water and aquifer wells are routinely sampled for the COCs chromium, tritium, Co-60, and Sr-90. Previously, perched water and aquifer wells were sampled for the radiological contaminants Am-241, Cs-137, Co-60, Sr-90, and H-3 and the inorganic contaminants arsenic, beryllium, cadmium, chromium, fluoride, lead, manganese, and mercury. Water quality results show little impact (most levels are near the detection limits) for Am-241, Cs-137, arsenic, beryllium, cadmium, fluoride, lead, manganese, and mercury. In addition to sampling for contaminants, water levels are collected from monitoring wells located near the RTC as part of routine monitoring activities. The United States

Geological Survey also monitors selected wells at the RTC, and data from the monitoring are used to supplement information collected under CERCLA-driven monitoring.

2.4.5 Ecological Risk Screening Evaluation

An ecological evaluation (EDF-6705) was conducted on the contaminants associated with the ETR Complex using a screening approach to evaluate risk to ecological receptors. The approach used the same scenarios and soil concentrations used in the surface pathway human health risk screening from Section 2.4.1.1 and Table 2-3.

The screening results for radionuclides indicate that Co-60, H-3 (tritium), and Ni-63 exceed ecologically based screening levels (EBSLs) if the ETR vessel is left in place (Alternative 2). No radionuclide concentrations exceed the EBSLs for the alternatives that remove the ETR vessel.

The nonradiological materials that exceeded the EBSLs were chromium, copper, nickel, and silver. These four metals are relatively common throughout the belowground structures in piping, wiring, stainless steel, and utility systems, and therefore exceeded the EBSLs for the alternative that leaves the vessel in place and also for the alternative that removes the vessel. In the environment at this site, items such as wiring, piping, and stainless-steel debris will not degrade to a bioavailable form uniformly throughout this soil, as was calculated for the purposes of screening. The concentrations of COCs will be highly localized so it is unreasonable to assume they would pose a risk to ecological receptors at a population level. Therefore, the nonradiological materials are eliminated as an ecological concern.

3. IDENTIFICATION OF REMOVAL OBJECTIVES AND SCOPE

The ROD (DOE-ID 1997) and Appendix A of the Explanation of Significant Differences (DOE-ID 2000) for the RTC established RAOs for cleanup of contaminated soils near the RTC. This section identifies the removal action goals for the activities associated with this removal action.

3.1 Removal Action Objectives

The RAOs for this NTCRA are to perform final decommissioning of the ETR Complex consistent with the OU 2-13 RAOs to achieve the following:

- Inhibit direct exposure to radionuclide COCs that would result in a total excess cancer risk greater than 1 in 10,000 to 1 in 1,000,000 for current and future workers and future residents

- Inhibit ingestion of radionuclide and nonradiological COCs by all affected exposure routes (including groundwater, soil, and homegrown produce ingestion) that would result in a total excess cancer risk greater than 1 in 10,000 to 1 in 1,000,000 or a hazard index of 1 or greater for current and future workers and future residents

- Inhibit adverse effects to flora and fauna—as determined from the ecological risk evaluation—from COCs in the soil, surface water, and air.

Although decommissioning the ETR Complex is not specifically addressed in the ROD (DOE-ID 1997), these removal action goals are consistent with the RAOs for contaminated soil established in that document. The removal action goals also are predicated on the current and future land uses established in the ROD (DOE-ID 1997) for the RTC area, which include industrial land use until at least 2095 and the potential for residential land use thereafter. Actions conducted under this NTCRA would be reviewed with DEQ and EPA for continued protectiveness during the Sitewide CERCLA five-year review process prescribed under the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991).

4. IDENTIFICATION OF REMOVAL ACTION ALTERNATIVES FOR THE ENGINEERING TEST REACTOR COMPLEX

The four alternatives under consideration for the ETR Complex NTCRA are discussed in the following sections.

4.1 Alternative 1—No Action Continued Surveillance and Maintenance

Under the no action alternative, no removal action would be conducted on the ETR vessel and there would be no removal of hazardous substances beyond what is being done under the VCO (DEQ 2000) and deactivation activities. This alternative would evaluate the ETR Complex subsequent to VCO and deactivation activities. Current surveillance and maintenance activities would continue. The no action alternative is included for completeness and comparative purposes. However, the alternative only defers taking further action upon the ETR Complex to a future date.

The VCO and deactivation activities include removal of hazardous substances such as RCRA hazardous waste and other waste and materials regulated by TSCA (15 USC § 2601 et seq.) and "National Emission Standards for Hazardous Air Pollutants" (40 CFR 61). Structures and systems, including piping and utility systems, will be abandoned in place. Therefore, the physical configuration to be considered under the no action alternative would include the reactor building, ETR vessel, and the internals left in place. In addition, hazardous substances not removed under the VCO (DEQ 2000) and deactivation activities would remain in place. Void spaces would not be backfilled.

4.2 Alternative 2—Grouting ETR Vessel in Place

For Alternative 2, the ETR vessel would be filled with a grout and the aboveground portions of the vessel would be encapsulated in a concrete monolith. The aboveground reactor building would be demolished. Belowgrade structures and systems, including piping, utility systems, and structural steel, would be abandoned in place. In addition, residual radioactive materials in the ETR Complex remaining after D&D activities are complete would remain in place and would be managed under the Sitewide Institutional Control Program. Void spaces would be grouted as necessary and/or backfilled as practicable using inert demolition waste from the abovegrade structures and clean backfill materials.

4.3 Alternative 3—Removal and Disposal of ETR Vessel at an On-Site Disposal Facility

Alternative 3 would include removal and disposal of the ETR vessel with vessel internal components intact at an on-Site disposal facility such as the ICDF or the Radioactive Waste Management Complex (RWMC). The reactor building would be demolished to ground surface; structures and systems below ground surface consisting of inert materials, such as piping, tanks, structural metal, and utility systems, would be abandoned in place. Residual radioactive materials in the ETR Complex remaining after D&D activities are completed would stay in place and would be managed under the Site-wide Institutional Control Program. Void spaces would be backfilled as practicable, including the void left by removal of the ETR vessel. Backfill would consist of grout, as necessary, and/or inert demolition waste from the abovegrade structures and clean backfill materials.

The vessel will be grouted to stabilize the internal reactor components during transportation and to meet required disposal facility Waste Acceptance Criteria (WAC) (DOE-ID 2005) for reducing void space to prevent subsidence.

4.4 Alternative 4—Removal and Disposal of ETR Vessel at an Off-Site Disposal Facility

Alternative 4 results in the same end state for the ETR Complex as Alternative 3. The ETR vessel is disposed of at an off-Site disposal facility. To allow for disposal off Site, the vessel has to meet Department of Transportation (DOT) packaging and shipping requirements. To meet these requirements, the vessel would be separated (cut) into the upper vessel tank and the lower vessel tank. This lower vessel tank contains the majority of the radioactive components and would be packaged to meet DOT packaging requirements. Both top and bottom sections would be transported separately to an off-Site disposal facility.

5. ALTERNATIVE ANALYSIS

In accordance with the *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA* (EPA 1993), the EE/CA for NTCRA alternatives will be evaluated with respect to three criteria: (1) effectiveness, (2) implementability, and (3) cost.

Effectiveness includes two subcriteria: protectiveness and the ability to meet the RAOs. Protectiveness was evaluated based on (1) protectiveness of the alternative for public health and the community, (2) protectiveness of workers during implementation, (3) protectiveness of the environment, and (4) compliance with applicable or relevant and appropriate requirements (ARARs) and other requirements.

Implementability is evaluated based on technical feasibility; availability of equipment, personnel, services, and disposal facilities; and administrative feasibility. Costs are estimated, including capital costs, operations and maintenance costs, and present net worth costs.

The no action alternative (Alternative 1) is included in this EE/CA for completeness. Under Alternative 1, only ongoing surveillance and maintenance activities continue. Under Alternative 1, the RAOs are not met, because the alternative does not address future risks. Because Alternative 1 is only considered an interim measure that delays a needed future action, the alternative is not carried forward for the detailed analysis. However, the alternative is included for comparative purposes in the cost analysis. Figure 5-1 shows a conceptual end state for the ETR Complex with the buildings and structures removed. Table 5-1 is a comparison of the major aspects of the four EE/CA alternatives.

5.1 Effectiveness of the Alternatives

The two subcriteria for evaluating effectiveness are protectiveness and the ability to meet the RAOs.

5.1.1 Protectiveness

Protectiveness is the primary objective of a removal action and is a threshold criterion that must be met to consider an alternative. The sections below addresses protectiveness for a hypothetical future resident (public health), a current worker, and the environment for each alternative.

5.1.1.1 Protectiveness: Public Health. As previously discussed in Section 2.4.5, Alternative 2 presents an unacceptable carcinogenic risk to a potential future resident at the location. The primary risk driver under Alternative 2 is the external exposure pathway resulting from Nb-94. Nb-94 is mostly contained in the vessel internals, specifically the vessel grid plate. The radioactive half-life of Nb-94 is 20,300 years; therefore, the protectiveness of the concrete containment enclosure and institutional controls would become increasingly uncertain with time. The most protective alternatives are Alternatives 3 and 4, which both require removal of the ETR vessel. For the alternative involving disposal at the ICDF (Alternative 3), the topmost portion of the vessel would reside roughly 20 ft below the ground surface and covered to grade, then a final cover more than 15 ft thick would also be placed above the vessel, placing the ETR vessel roughly 35 ft (10.7 m) below the top of the cover. Therefore, for the external exposure pathway, disposal at ICDF is more protective for a future resident than leaving the vessel in place. Although disposal of the vessel at the ICDF would be in compliance with the WAC and other short-term and long-term requirements, it would incrementally add to the total allowable radioactive source term for specific radionuclides. Therefore, when compared against Alternative 4, which provides for vessel disposal at the Nevada Test Site (NTS), Alternative 4 is ranked somewhat higher in long-term protectiveness of the groundwater below the ICDF as it does not add to the ICDF source term. Under these alternatives, no unacceptable risks remain at the location of the ETR Complex. Alternative 4 presents increased public hazards, both real and perceived, during transportation of the vessel over public highways and through congested metropolitan areas between the INL and an off-Site disposal facility.

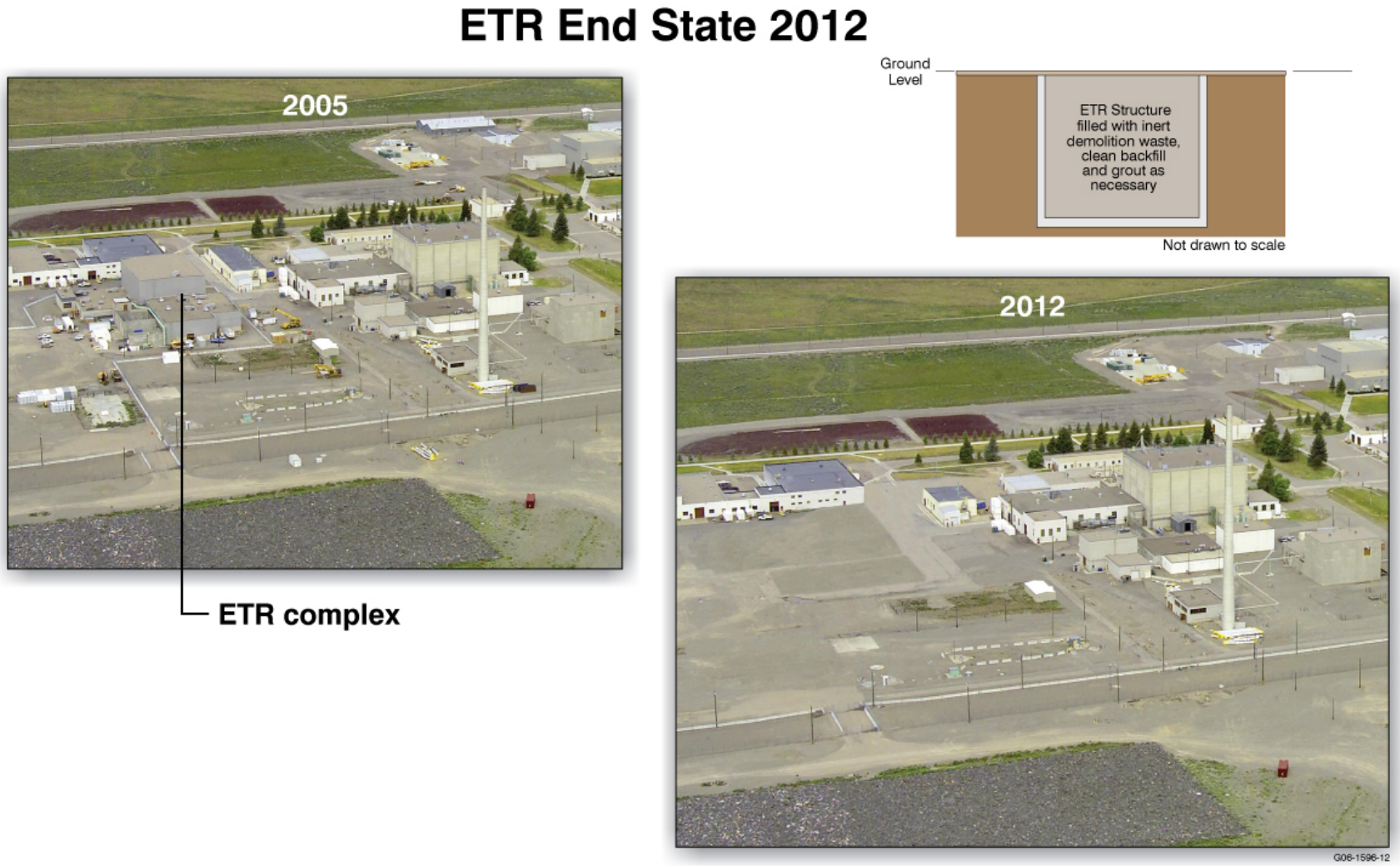

Figure 5-1. Conceptual end state for the Engineering Test Reactor Complex with the buildings and ETR vessel removed.

Table 5-1. Major aspects of the four engineering evaluation/cost analysis alternatives.

End State	Alternative 1 No Action	Alternative 2 Grouting ETR Vessel in Place	Alternative 3 Removal and Disposal of ETR Vessel at On-Site Disposal Facility	Alternative 4 Removal and Disposal of ETR Vessel at Off-Site Disposal Facility
Reactor building remains	✓			
Reactor building demolished to grade		✓	✓	✓
ETR vessel remains in place	✓	✓		
ETR vessel removed			✓	✓
ETR vessel disposed of at on-Site disposal facility			✓	
ETR vessel disposed of off-Site				✓

Since Alternative 2 does not meet the threshold criteria for protectiveness of human health, it is screened out from further evaluation. Alternatives 3 and 4 are carried forward in this evaluation. In the year 2095 the specific activity remaining for Alternatives 3 and 4 in the soil at the ETR Complex due to the contamination remaining after removal of the ETR vessel and D&D is approximately 8 pCi/g of primarily Ni-63.

5.1.1.2 Protectiveness: Worker Risk. Alternative 4 has a much higher radiological risk to the worker than Alternative 3. Alternative 4 requires workers to be in much higher dose areas of the reactor vessel during preparation of the vessel for packaging. To meet DOT packaging requirements for over-the-road shipments, the vessel would have to be reduced in size and weight to allow handling and transportation. The upper portion of the vessel would be cut from the lower portion. It is estimated that the workers completing this sizing activity would acquire an additional 15 person-rem of radiation exposure for Alternative 4 as compared to Alternative 3. Also, there would be an increased risk to the worker for Alternative 4 due to increased potential for exposure during the packaging of the vessel and transporting the ETR vessel to an off-Site disposal facility. Packaging requirements for transportation are further discussed in Section 5.2.1.

Alternative 4 involves greater industrial safety risk to workers than Alternative 3 because workers would be in close proximity to hoisting, rigging, and cutting activities. These activities are required to cut the reactor vessel into two pieces and package the vessel for off-Site disposal. Alternative 4 would also present increased worker hazards to place the ETR vessel in a package for over-the-road shipment to an off-Site disposal facility.

Alternative 3 is the most protective because sizing of the ETR vessel is not required for transportation to the ICDF or RWMC and provides the greatest protection to the worker from industrial safety and radiological exposure. Transportation requirements are discussed in more detail in Section 5.2.1.

5.1.1.3 Protectiveness: Environmental Risk. As discussed in Section 2.4.5, no radionuclide concentrations exceed the EBSLs for the alternatives that remove the ETR vessel (Alternatives 3 and 4); therefore, risk to ecological receptors at a population level for nonradiological constituents left at the ETR Complex was eliminated as an ecological concern.

5.1.2 Protectiveness: Ability to Achieve Removal Action Objectives

Alternatives 3 and 4 achieve the RAOs by removing and shipping the ETR vessel, which contains the contaminant inventory presenting the unacceptable risk, to an approved disposal facility consistent with the ROD (DOE-ID 1997) and the Explanation of Significant Differences (DOE-ID 2000).

5.2 Implementability of the Alternatives

Implementability is evaluated based on technical and administrative feasibility and availability of equipment, personnel, services, and disposal facilities.

5.2.1 Technical and Administrative Feasibility

Alternatives 3 and 4 are both technically feasible. The methods for performing these activities can be planned and engineered using existing available knowledge and procedures and have been performed at the INL or elsewhere. Alternative 4 is more technically and logistically challenging from the standpoint of packaging the vessel and transporting for off-Site disposal. Off-Site transportation will require complex coordination with city, county, and state entities to develop and implement transport plans and permits. The high-radioactivity content of the vessel internals requires the vessel to be contained in a robust container to meet the DOT requirements. The DOT requirements (49 CFR 173) indicate that the vessel may have to be packaged in a DOT Type B package for off-Site shipment to ensure protection of the public during transport. Type B packages are highly engineered overpack-type structures, requiring rigorous testing and permitting.

5.2.2 Availability of Equipment, Personnel, and Services

Equipment to support Alternatives 3 and 4 is either available at the INL or commercially available. Cranes capable of heavy lifts greater than the combined weight of the ETR vessel, internals, and grout are commercially available, as are industrial jacks, which may be utilized in removing the grouted ETR vessel. Advanced cutting methods are available to cut the vessel into sections for packaging in DOT-compliant containers. Multiaxle transport vehicles are available to transport weights in excess of 150 tons that the vessel and additional shielding may require. The Type B package required to ship the ETR vessel off-Site is not readily available and would require a package to be designed, fabricated, and tested specifically for the ETR.

Trained personnel are available to perform Alternatives 3 and 4.

On-Site or off-Site disposal or recycling services are available for most waste generated for all alternatives with the potential exception of the ETR vessel and/or ETR vessel internals, which are further evaluated in Section 5.3.

5.3 Implementability of Vessel Transportation and Disposal

This section evaluates the low-level waste (LLW) disposal options and associated transportation requirements for the intact ETR vessel in accordance with Alternatives 3 and 4.

Nine disposal sites and the associated transportation means are identified and screened for viability. The disposal facilities include both DOE and U.S. commercial sites which are disposal facilities that can accept DOE LLW. Energy Solutions of Utah—the ninth facility evaluated—is the exception, as it is permitted to accept only Class A waste. Transportation and disposal evaluations are conducted for two EE/CA alternatives—3 (on-Site disposal) and 4 (off-Site disposal). Although Alternative 3 is specific for disposal at the ICDF, for completeness, on-Site disposal options evaluated in this EE/CA will include both the RWMC and the ICDF.

5.3.1 Initial Screening for Viable Disposal Facilities for the ETR Vessel

Two DOE on-Site, three DOE off-Site, and four commercial off-Site disposal facilities are evaluated. The waste package characteristics are evaluated against each disposal facility's acceptance criteria, administrative requirements, schedule availability, and transportation options. For Alternatives 3 and 4, the vessel is assumed to be grouted to stabilize the internals and meet the required WAC for reducing void space to prevent subsidence.

Under Alternative 3, the waste package is the entire ETR vessel with the internals intact. For Alternative 4, the waste package is only the lower section of the vessel to allow packaging to meet DOT requirements while reducing weight of the waste package to facilitate handling and transportation to an off-Site disposal facility.

To determine if the ETR vessel waste package meets the WAC for disposal at the facilities evaluated, the standard industry practice of averaging the concentrations of radioactive and nonradioactive components over the weight of the entire waste package is employed. The waste package must also comply with requirements of DOT if the waste package is transported off-Site (Alternative 4). Transportation on-Site would not need to comply with DOT requirements because the vessel never "enters commerce," the threshold criteria for invoking the DOT requirements.

5.3.1.1 Alternative 3—Disposal of the Engineering Test Reactor Vessel at an On-Site Disposal Facility. In Alternative 3, the ETR vessel with intact internal nonfuel components would be disposed of at an on-Site facility. Two on-Site facilities are evaluated to satisfy this alternative.

5.3.1.1.1 ***Idaho CERCLA Disposal Facility—***The ICDF is a state-of-the-art, multiple-lined, and monitored on-Site disposal facility that accepts CERCLA waste generated at the INL Site. The ETR vessel meets all WAC for disposal at the ICDF. Transportation and disposal at the ICDF are relatively simple because no public highways are involved and the vessel can be transported the approximately 3 miles to the disposal site without having to meet the rigorous requirements imposed by DOT (both federal and state) for shipment of a radioactive waste package the many hundreds of miles to an off-Site disposal facility. The ICDF is a viable alternative and is carried forward in this EE/CA.

5.3.1.1.2 Radioactive Waste Management Complex—The unlined LLW pit at the RWMC, anticipated to close to contact-handled LLW at the end of 2008, provides a second on-Site disposal option for the ETR waste package. The ETR vessel meets all WAC for disposal at RWMC; however, disposal at the RWMC is deemed inappropriate because it is currently a CERCLA site, regulated under the Idaho National Engineering and Environmental Laboratory Federal Facility Agreement and Consent Order (DOE-ID 1991), and disposal of additional CERCLA waste requires DOE-ID, EPA, and DEQ approval. Complex disposal logistics exist for disposal at the RWMC, as space in the disposal pit is very limited. Pit space for disposing of the waste package will need to be reserved to meet handling requirements and crane accessibility. Barriers also will need to be installed to prevent disturbing previously buried waste and to permit continued disposal activities. Transporting the waste requires a heavy haul on Site roads over buried waste in the RWMC Subsurface Disposal Area. Safely staging a crane by the side of or on top of the LLW presents additional issues. Transportation of the ETR

vessel to RWMC would also require crossing Highway 20/26, a public highway. Because of these issues, although viable, the RWMC disposal option is less desirable than the ICDF disposal option.

5.3.1.2 Engineering Evaluation/Cost Analysis Alternative 4—Disposal at an Off-Site Disposal Facility. In Alternative 4, the ETR vessel with internal nonfuel reactor components would be disposed of at an off-Site facility. Under this alternative, the vessel and internals would be grouted to stabilize internal components and to meet the disposal facilities' WAC. It is assumed that the vessel, with the internals intact, would be classified as a waste with higher than Class A radionuclide concentrations. Seven off-Site facilities are evaluated to satisfy this alternative. Off-Site disposal requires an EPA "offsite determination" prior to shipment to an off-Site receiving facility.

5.3.1.2.1 U.S. Department of Energy Disposal at the Nevada Test Site in Nevada—This option would transport and dispose of the ETR waste package at the NTS. The transportation logistics for moving the ETR would combine multiple crane lifts, over-the-road heavy hauls, and, possibly, railroad heavy hauls. Though complex, the transportation support does exist to move the waste package from the INL to the NTS. Because the NTS does not currently have railroad access into the Site, the railroad option would require the development and/or use of a railroad siding on the Union Pacific track near the NTS to off-load the waste package from the railroad car to the road's heavy-haul system. Waste characterization information compiled for the ETR vessel has been presented to the technical waste acceptance board at NTS for a preliminary review. NTS indicated that disposal at the NTS waste disposal facility was a viable alternative. The ETR vessel waste package must be reviewed and approved by a NTS waste acceptance board. NTS is a viable alternative and is carried forward in this evaluation.

5.3.1.2.2 U.S. Department of Energy Disposal at Hanford in Washington—Disposal at Hanford is complicated by two major unresolved issues. The Washington voters passed an initiative in 2004 prohibiting further disposal of out-of-state, DOE-generated waste at disposal facilities located in the State of Washington. Although a recent decision in federal court upholds DOE's right to dispose of nuclear materials in the State of Washington, it is expected that the decision will be appealed and may not be resolved in a timeframe that would support disposal of the ETR vessel. Disposal at this site is further complicated by a Hanford environmental impact statement that limits total disposal volume to 65,000 m^3 (DOE 1999), which does not include the ETR vessel. In addition, the Low Level Burial Ground (the only Hanford disposal facility open to off-Site CERCLA waste) requires an approved EPA ROD for disposal of CERCLA-generated, off-Site waste. Based on these obstacles to disposal, this disposal site is not carried forward in this evaluation.

5.3.1.2.3 U.S. Department of Energy Disposal at Oak Ridge, Tennessee—The DOE Oak Ridge disposal facility in Tennessee cannot receive off-Site LLW. Therefore, this option is screened out from further evaluation.

5.3.1.2.4 Commercial Disposal at Barnwell, South Carolina—Barnwell, South Carolina, is a commercial disposal facility considered as a disposal option. At the beginning of 2008, Barnwell is scheduled to enter into a compact with three eastern states. At that time, the site will receive waste from only the compact states. In order for Barnwell to receive a waste package, the State of South Carolina would have to approve a petition in a timely fashion. The transportation logistics for moving the ETR would combine multiple crane lifts, over-the-road heavy hauls, and railroad heavy hauls across nearly the entire width of the country. Though complex, transportation support does exist to move the waste package from the INL to Barnwell. However, this option is screened out from further evaluation because of the complexity of the cross-country transport and the logistics of waste acceptance with both the disposal facility and the State of South Carolina.

5.3.1.2.5 Commercial Disposal at U.S. Ecology at Hanford, Washington—

Disposal at U.S. Ecology is complicated by the unresolved voter initiative issue. In 2004, the Washington voters passed an initiative prohibiting further disposal of out-of-state, DOE-generated waste at Washington disposal facilities. Although the initiative is currently being challenged in the courts, it clouds disposal planning and scheduling activities.

The State of Washington would need to approve a petition in order for a waste package exceeding Class C criterion to be accepted at U.S. Ecology. This option is screened out from further evaluation because of the complexity of the unresolved issues and transport along with the logistics of waste acceptance with both the disposal facility and the State of Washington.

5.3.1.2.6 Commercial Disposal at Waste Control Specialists in Texas—

Waste Control Specialists in Texas is a commercial disposal facility considered as a disposal option. Waste Control Specialists is in the process of applying for a Nuclear Regulator Commission (NRC) license to accept Class A, B, and C low-level radioactive waste and does not anticipate receiving a license until after 2007. The ETR vessel exceeds the Waste Control Specialists limit for Ni-63 (in activated metals) and presents a significant impact with the curie amounts of Nb-94, Cl-36, and C-14 (in activated metals) to the total allowable disposal inventory. Therefore, this disposal facility is screened out from further evaluation.

5.3.1.2.7 Commercial Disposal at Energy Solutions of Utah—

Energy Solutions of Utah is a commercial disposal facility considered as a disposal option. Energy Solutions is limited to accepting only NRC Class A waste. The ETR waste package has radionuclide concentrations greater than NRC Class A. For this reason, this option is screened out from further evaluation.

5.3.2 Results of ETR Vessel Disposal Options Evaluation

The above evaluation results have identified the two most viable disposal/transportation options. On-Site disposal at ICDF is a viable option and is carried forward under Alternative 3. Off-Site disposal at the Nevada Test Site is also a viable disposal option and is carried forward under Alternative 4.

5.4 Cost of the Alternatives

Detailed cost estimates have been prepared for the four alternatives evaluated in this EE/CA. The estimates were prepared in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000b). Costs are calculated for both capital expenditures and future operation and maintenance expenses. In accordance with EPA guidance, the cost for the alternatives over time is calculated as present net worth costs, which are sometimes referred to as net present value, to represent the costs in 2006 dollars. For Alternative 1, it is assumed, for comparison purposes, that the current surveillance and maintenance costs continue through the year 2095. For Alternatives 3 and 4, removal of the ETR vessel is assumed to occur during the spring/summer of 2007, and demolition of the TRA-642 abovegrade structures commences in the fall of 2007. The end state is assumed to be achieved by the spring of 2008 with long-term institutional controls instituted starting in 2008, and inspections occurring annually through 2095. In the case of Alternative 2, it assumed that maintenance of the containment structure over the ETR vessel would also require minor maintenance once every 5 years through the institutional control period. Although institutional controls under Alternatives 1 and 2 would be needed well beyond 2095, costs are only estimated over the next 90 years for the purposes of preparing the cost comparison.

The information in the cost estimate summary is based upon the best available information regarding the anticipated scope of the removal action alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design and performance of the removal action. Major changes will be documented in the form of a memorandum placed into the Administrative Record file. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30% of actual project cost. The cost estimate summary is presented in Table 5-2.

Table 5-2. Cost estimates for no action and removal action alternatives.

Feature	Alternative 1 No Action with Continued Surveillance and Maintenance	Alternative 2 Grouting ETR Vessel in Place	Alternative 3 Removal and Disposal of the ETR Vessel at an On-Site Facility	Alternative 4 Removal and Disposal of the ETR Vessel at an Off-Site Disposal Facility
D&D Costs	$0	$4,415,396	$6,442,243	$20,147,726
Operation and Maintenance Costs (current value)	$33,350,950	$584,856	$584,856	$584,856
Net Present Value Cost	$11,804,418	$4,457,863	$6,417,515	$18,912,983

5.5 Summary of Alternative Evaluation

Alternative 1, the no action alternative, is included for completeness and comparative purposes. However, the alternative only defers taking further action upon the ETR Complex to a future date and does not address the potential for adverse threat to human health and potential threat of release of hazardous substances to the environment and is not recommended for these reasons.

Alternative 2 grouts the ETR vessel in place. Because Alternative 2 does not meet the threshold criteria for protectiveness of human health, it cannot be a recommended alternative.

Only Alternatives 3 and 4 were evaluated for the recommended alternative.

Alternative 3 removes the ETR vessel and demolishes the reactor building to ground surface. The ETR vessel would be disposed of at an on-Site disposal facility (ICDF or RWMC). This alternative meets the RAOs established in the OU 2-13 ROD. Compared to Alternative 4, Alternative 3 provides the most protection for the worker and costs less.

Alternative 4 also removes the ETR vessel, demolishes the reactor building to ground surface and meets the RAOs; however the ETR vessel would be disposed of at the Nevada Test Site. Compared to Alternative 3, Alternative 4 poses greater risk for the worker and costs more; however, Alternative 4 is ranked somewhat higher in long-term protectiveness of the groundwater below the ICDF than Alternative 3 as it does not add to the ICDF source term.

6. RECOMMENDED REMOVAL ACTION ALTERNATIVE

DOE-ID recommends implementation of Alternative 3, "Removal and Disposal of the ETR Vessel at an On-Site Disposal Facility," with disposal at the ICDF. The ICDF is a state-of-the-art, multiple-lined, and monitored on-Site disposal facility that offers greater protection to human health and the environment than disposal at the unlined disposal cells at RWMC. The vessel would be filled with grout (as necessary) to stabilize vessel internals and reduce radiological dose. The ETR vessel would be transported and disposed of as low-level radioactive waste at the ICDF. Any remaining voids in the vessel would be filled with grout at the disposal site.

The aboveground portions of the reactor building would be demolished to below ground surface and the resultant demolition material may be used as backfill or disposed of in accordance with the applicable disposal site WAC. Materials left in place include inert, nonputrescible material located below the ground surface, such as piping, equipment, electrical conduit, utility systems, structural steel, and other residual clean or contaminated materials with low-level radioactive and/or chemically hazardous substances that do not present an unacceptable risk in accordance with the RAOs for the ROD (DOE-ID 1997) and the Explanation of Significant Differences (DOE-ID 2000). Excavations and remaining belowgrade structures will be backfilled to grade. Clean soil would cover the locations of the ETR Complex buildings and structures.

The recommended alternative meets the proposed RAOs regarding long-term risk, minimizes short-term worker risk and radiation exposure, is cost effective, and provides a safe and stable configuration that is environmentally sound. The DOE-ID also considers Alternative 3 consistent with the RAOs of the ROD (DOE-ID 1997) and compliant with ARARs.

6.1 Compliance with Environmental Regulations

Section 121 of CERCLA (42 USC § 9621) requires the responsible CERCLA implementing agency to ensure that the substantive standards of HWMA/RCRA and other applicable laws will be incorporated into the federal agency's design and operation of its long-term remedial actions and into its more immediate removal actions. The DOE-ID is the implementing agency for this NTCRA. Both the DEQ and the EPA concur that an NTCRA is warranted to protect human health and the environment. Through the NTCRA process, the risks presented in this document will be mitigated in a timely manner.

Table 6-1 lists the proposed ARARs that have been identified for this removal action. These ARARs are a compilation and expansion of the ARARs identified in the ROD (DOE-ID 1997). The ARARs list is based on several key assumptions:

- Any residual contamination left in place will meet the RAOs established in the ROD (DOE-ID 1997).

- Liquid waste (e.g., radioactive water) is assumed to have been removed from the ETR Complex prior to initiation of the NTCRA. The liquid waste will have been previously addressed through the VCO Program and other regulatory activities intended to place the facility in an environmentally safe condition. Any residual liquid would be disposed of in accordance with the receiving disposal facility's WAC.

Table 6-1. Summary of applicable or relevant and appropriate requirements for the Engineering Test Reactor Complex non-time-critical removal action.

Requirement (Citation)	ARAR Type	Comments
Clean Air Act and Idaho Air Regulations		
"Toxic Substances," IDAPA 58.01.01.161	A	Applies to any toxic substances emitting during implementation of the removal action.
<10 mrem/yr, 40 CFR 61.92, "Standard"	A	Applies to the waste handling activities.
"Emission Monitoring and Test Procedures," 40 CFR 61.93	A	Applies to the waste handling activities.
"Compliance and Reporting," 40 CFR 61.94(a)	A	Applies to the waste handling activities.
"Standard for Demolition and Renovation," 40 CFR 61.145	A	Applies to any asbestos-containing materials removed during the decommissioning.
"Rules for Control of Fugitive Dust," and "General Rules," IDAPA 58.01.01.650 and .651	A	Applies to the waste handling activities.
Idaho Solid Waste Facilities Act		
"Applicable Requirements for Tier II Facilities," IDAPA 58.01.06.012	A	Applies to disposal of solid wastes at the CFA landfill.
RCRA and Idaho Hazardous Waste Management Act		
Generator Standards:		
"Standards Applicable to Generators of Hazardous Waste," IDAPA 58.01.05.006, and the following, as cited in it:		
"Hazardous Waste Determination," 40 CFR 262.11	A	Applies to waste that would be generated during the removal action.
General Facility Standards:		
IDAPA 58.01.05.008, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," and the following, as cited in it:		
"Temporary Units (TU)," 40 CFR 264.553	A	Waste may be treated or temporarily stored in a temporary unit prior to disposal.
"Staging Piles," 40 CFR 264.554	A	Waste may be temporarily staged prior to disposal.
"General Inspections Requirements," 40 CFR 264.15	A	Applies to a facility staging, storing, or treating hazardous waste prior to transfer to the ICDF or an off-Site facility.
"Preparedness and Prevention," 40 CFR 264, Subpart C	A	Applies to a facility staging, storing, or treating hazardous waste prior to transfer to the ICDF or an off-Site facility.

Table 6-1. (continued).

Requirement (Citation)	ARAR Type	Comments
"Contingency Plan and Emergency Procedures," 40 CFR 264, Subpart D	A	Applies to a facility staging, storing, or treating hazardous waste prior to transfer to the ICDF or an off-Site facility.
"Disposal or Decontamination of Equipment, Structures, and Soils," 40 CFR 264.114	A	Applies to contaminated equipment used to remove, treat, or transport hazardous waste.
"Use and Management of Containers," 40 CFR 264.171–178	A	Applies to containers used during the removal and treatment of hazardous waste.
Land Disposal Restrictions:		
IDAPA 58.01.05.011, "Land Disposal Restrictions," and the following, as cited in it:		
"Applicability of Treatment Standards," 40 CFR 268.40(a)(b)(e)	A	Applies to hazardous waste and secondary waste, if treatment is necessary to meet the disposal facility's WAC or if treatment is required before placement.
"Treatment Standards for Hazardous Debris," 40 CFR 268.45	A	Applies to hazardous debris, if treatment is necessary to meet the disposal facility's WAC or if treatment is required before placement.
"Universal Treatment Standards," 40 CFR 268.48(a)	A	Applies to nondebris hazardous waste and secondary waste, if treatment is necessary to meet the disposal facility's WAC or if treatment is required before placement.
"Alternative LDR Treatment Standards for Contaminated Soil," 40 CFR 268.49	A	Applies to contaminated soil, if treatment is necessary to meet the disposal facility's WAC or if treatment is required before placement.
IDAPA 58.01.05.016, "Standards for Universal Waste Management"		
"Standards for Large Quantity Handlers of Universal Waste," 40 CFR 273 Subpart C	A	Applies to management of universal wastes.
Idaho Groundwater Quality Rules		
"Ground Water Quality Rule," IDAPA 58.01.011	A	The waste handling activities must prevent migration of contaminants from the reactor complex that would cause the Snake River Plain Aquifer groundwater to exceed applicable State of Idaho groundwater quality standards in 2095 and beyond.
TSCA		
"Decontamination Standards and Procedures: Decontamination Standards," 40 CFR 761.79(b)(1)	A	Applicable to decontamination of equipment with PCB contamination, if PCB waste is generated.
"Decontamination Standards and Procedures: Self-Implementing Decontamination Procedures," 40 CFR 761.79(c)(1) and (2)	A	Applicable to decontamination of equipment with PCB contamination, if PCB waste is generated.

Table 6-1. (continued).

Requirement (Citation)	ARAR Type	Comments
"Decontamination Standards and Procedures: Decontamination Solvents," 40 CFR 761.79(d)	A	Applicable to decontamination of equipment used to manage PCB-contaminated waste, if PCB waste is generated.
"Decontamination Standards and Procedures: Limitation of Exposure and Control of Releases," 40 CFR 761.79(e)	A	Applicable to decontamination activities of equipment with PCB-contaminated waste, if decontamination is performed.
"Decontamination Standards and Procedures: Decontamination Waste and Residues," 40 CFR 761.79(g)	A	Applicable to management of decontaminated waste and residuals from PCB-contaminated equipment, if PCB waste is generated.
Department of Transportation		
49 CFR 173	A	Applicable for packaging and transportation of the ETR vessel off the INL.
To-Be-Considered Requirements		
"Radiation Protection of the Public and the Environment," DOE Order 5400.5, Chapter II(1)(a,b)	TBC	Applies to the ETR Complex before, during, and after the removal action. Substantive design and construction requirements would be met to keep public exposures as low as reasonably achievable.
"Radioactive Waste Management," DOE Order 435.1	TBC	Applies to the ETR Complex before, during, and after the removal action. Substantive design and construction requirements would be met to protect workers.
Region 10 Final Policy on the Use of Institutional Controls at Federal Facilities (EPA 2006)	TBC	Applies to residual waste following completion of the removal action.

A = applicable requirement; R = relevant and appropriate requirement; TBC = to be considered.

ARAR = applicable or relevant and appropriate requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ETR = Engineering Test Reactor
ICDF = Idaho CERCLA Disposal Facility
IDAPA = Idaho Administrative Procedures Act
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
TSCA = Toxic Substances Control Act

- The majority of lead shielding will be removed from the ETR Complex prior to initiation of the NTCRA through other regulatory activities intended to place the facility in an environmentally safe condition. However, some lead may remain following these activities, which may require management under the scope of the NTCRA as CERCLA waste. Removed lead that cannot be recycled or reclaimed shall be declared a hazardous waste or mixed LLW and will be disposed of at an off-Site disposal facility in accordance with the disposal facility WAC.

- Management of CERCLA waste generated during the removal action would be subject to meeting the ICDF's WAC (DOE-ID 2005).

- If decontamination liquids are generated, they will be disposed of at the ICDF evaporation ponds in accordance with the approved WAC.

- Debris generated during removal of the vessel might have paint that contains PCBs. If encountered, such waste may trigger substantive requirements of the TSCA (15 USC § 2601 et seq.). Lead-contaminated paint also may be removed during recovery of the shielding lead, which would be subject to the substantive requirements of RCRA hazardous waste regulations. Nonhazardous waste would be disposed of at the ICDF, unless it can be demonstrated that it is eligible for disposal as solid waste at the Central Facilities Area Landfill Complex. The PCB-containing light ballasts are planned for removal from the building prior to this removal action.

- Asbestos-containing material, which is both friable and nonfriable, may be encountered incidental to performance of the NTCRA. Friable or regulated asbestos-containing material is subject to specific asbestos regulations and would be acceptable for disposal at the ICDF and/or, if not radiologically contaminated, at the Central Facilities Area Asbestos Landfill. Regulated asbestos will be removed and disposed of as required by 40 CFR 61.150, "Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations." Undisturbed asbestos or asbestos found in high-radiation, high-contamination, and/or inaccessible locations greater than 3 ft below the ground surface may be left in place.

- Mercury located in mercury fluorescent lamps is planned for removal prior to this removal action under other regulatory activities intended to place the facility in an environmentally safe condition, as would the mercury-containing electrical switches and lights. No mercury is expected to be present in the building substructure at the start of the removal action.

6.2 Cultural Resources

Section 106 of the National Historic Preservation Act of 1966 (NHPA) (16 USC § 470 et seq.), as amended, requires agencies to consider the impact of undertakings on properties listed or eligible for listing in the National Register of Historic Places and to consult with the Idaho State Historic Preservation Officer and other interested parties when impacts are likely. It also requires federal agencies to invite the Advisory Council on Historic Preservation to participate in consultation when impacts may be adverse. The NHPA Section 106 process has been tailored to meet the unique needs of the INL Site. Section 110 of the NHPA directs federal agencies to establish programs to find, evaluate, and nominate eligible properties to the National Register of Historic Places, including previously unidentified historic properties that may be discovered during the implementation of a project (36 CFR 800). In addition, the Archaeological Resources Protection Act of 1979 (16 USC § 470aa–470mm), as amended, provides for the protection and management of archaeological resources on federal lands. Procedures and strategies to tailor these requirements to the unique needs of the INL Site are described in the INL Cultural Resource Management Plan (CRMP) (DOE-ID 2004b). The INL CRMP is implemented through a Programmatic

Agreement among DOE-ID, the Idaho State Historic Preservation Officer, and the Advisory Council on Historic Preservation.

The ETR Complex is a historic property, eligible for nomination to the National Register of Historic Places. DOE-ID has made the decision to proceed with demolition of the ETR Complex. To mitigate the adverse impacts caused by such action, DOE-ID—through measures outlined in the INL CRMP—has committed to the preservation of the ETR history through the completion of a Historic American Engineering Record report. The ETR Historic American Engineering Record report will ultimately be accessioned into the Library of Congress' permanent collections.

DOE is required to review as guidance the most current United States Fish and Wildlife Service list for threatened and endangered plant and animal species. DOE-ID determined that none of the alternatives would impact any threatened and endangered species and also determined that formal consultation with the United States Fish and Wildlife Service is not required for this action.

6.3 Compliance with Disposal Facility Waste Acceptance Criteria

6.3.1 ICDF Waste Acceptance Criteria

The ICDF is an on-Site disposal facility that accepts CERCLA waste generated at the INL. The ETR vessel meets the WAC for disposal at the ICDF. Grout will be added to stabilize the vessel internals for shipment and reduce void spaces to prevent subsidence in the disposal cell.

6.3.2 Achieving Removal Action Goals

The recommended Alternative 3 would meet the RAOs through removal and shipment of the ETR vessel to an approved disposal facility. The abovegrade portions of the ETR Complex would be rubbled into the basement areas or be removed and shipped to appropriate disposal facilities. The remaining belowgrade structures and void spaces at the ETR Complex would be grouted as necessary and backfilled to grade. Since the ETR vessel contains the contaminant inventory presenting the unacceptable risk, any residual contamination remaining in the subsurface, with the vessel removed, would present an acceptable risk, consistent with the RAOs established in the ROD (DOE-ID 1997) and the Explanation of Significant Differences (DOE-ID 2000).

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